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The Role of Trait and State Anxiety in Semantic Network Organization of Information Related to Current Concerns.

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THE ROLE OF TRAIT AND STATE ANXIETY IN SEMANTIC NETWORK
ORGANIZATION OF INFORMATION RELATED TO CURRENT CONCERNS

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Psychology

by

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Abstract

In the first study of this report, empirically-derived cognitive networks were established for high trait test anxious participants ($n = 28$) and low trait test anxious participants ($n = 25$) during periods of both high and low exam stress. Cognitive networks were created using the Pathfinder algorithm, which transforms pair-wise word similarity ratings into an associative network. Information included in the networks pertained to the following word categories: testing situations, positive performance evaluation, and negative performance evaluation. Contrary to predictions, there was no effect of either trait or state test anxiety on semantic network organization. These findings fail to support the associative network theory of anxiety and suggest the need for development of alternative explanations for biased cognitive processing associated with anxiety. Study number two investigated the validity of the Pathfinder algorithm by examining the relationship between Pathfinder-generated network organization and free-recall order, which represents a measure of organization of information in memory. Correlations were conducted for both high trait test anxious participants ($n = 21$) and low trait test anxious participants ($n = 23$). Findings only partially supported the validity of Pathfinder. Implications of these findings for use of Pathfinder in future research and clinical assessment are discussed.

Introduction

It is widely accepted that emotions are functional. Emotions alert individuals to environmental conditions which are relevant to current concerns, and motivate action toward satisfaction of an environmental goal (Frijda, 1994). One preservatory feature of emotions is to alert individuals to threatening environmental cues, which motivates safety-seeking behavior. Both fear and anxiety serve this function; however, these emotions are differentiated in terms of the temporal proximity of the threat cue. Specifically, fear occurs in response to a perceived immediate threat, usually resulting in a panic reaction, while anxiety occurs in response to an uncertain future threat, usually resulting in a state of "anxious apprehension" (Barlow, 1988)

The phenomenology of anxiety is a complex interaction of physiological, affective, behavioral, and cognitive system activation. However, in recent years increasing research interest has been focused on the role of cognitive processing in the initiation and maintenance of anxiety states (Williams, Watts, MacLeod, & Mathews, 1997). Much of this research is conducted using methodologies borrowed from cognitive science, in order to study human emotion from an information processing perspective. The information processing perspective focuses on the mechanisms responsible for perception, storage, manipulation, and retrieval of information within the cognitive system. Hypotheses tested in the growing empirical literature investigating the interplay between anxiety and cognitive processing are based primarily on general theories of cognition and emotion.

Several influential theories of cognition and emotion propose the existence of latent cognitive structures. For example, Beck, Rush, Shaw, and Emery (1979) proposed an underlying cognitive structure called a schema may influence the development and maintenance of emotional disorders. Schemas are latent cognitive structures of stored information which, when activated, drive the cognitive system to

process information in a fashion consistent with the schema. Specifically, anxious arousal causes activation of "danger schemata," and cognitive resources are biased to facilitate processing of threatening information (Beck, Emery, & Greenberg, 1985). Others have generated theories of cognitive structures that are analogous to memory organization (e.g., Anderson & Bower, 1973), with emotional information related to current concerns stored in the form of an associative network (Bower, 1981, 1987; Lang, 1977, 1979). These theories also propose that emotional arousal will activate cognitive structures, and bias subsequent cognitive processing in ways that are consistent with the emotional experience.

Extensive research supporting the hypothesis that anxiety is associated with biased cognitive processing has recently been reviewed (Williams et al., 1997). However, to date no research has quantified or illustrated cognitive structures associated with anxiety. As these hypothesized constructs form the basis of several influential theories, it is critical to establish this point empirically. A major obstacle to this goal is the unobservable nature of cognitive structures, which causes substantial measurement problems. However, recently a methodology called Pathfinder has been developed which transforms numerical self-report data into graphical representations of associative network mental models (Schvaneveldt, 1990). In recent years, Pathfinder has been used to illustrate knowledge structures associated with sexual information (Geer, 1996; Manguno-Mire & Geer, 1997; Rabalais & Geer, 1992; Smith, Eggleston, Gerrard, & Gibbons, 1996) and depression (Mascaro & Geer, 1999; Melton, 1995).

The goal of the present study was to apply the Pathfinder methodology to investigate the nature of cognitive structures associated with anxiety. Specifically this study focused on the situation-specific case of test anxiety. Because it has been proposed that associative networks represent a measure of memory organization, this study also tested the hypothesis that network models generated by Pathfinder can

predict performance on another, previously validated measure of memory organization (i.e., clustering of information in a free-recall task). Therefore, this investigation provides the most direct test to date of predictions made by cognitive theories of emotion.

Review of the Literature

Network Models

Network theories provide the conceptual framework for predictions investigated in this study. Therefore, a basic description of these theories will be provided.

Network models of emotion are derived from theories of semantic network organization in human memory (e.g., Anderson & Bower, 1973; Collins & Loftus, 1975). According to network models, semantic information is stored in the form of concept nodes.

Concept nodes that are related to one another are connected together with links, which represent association. The resulting cognitive structure of related concept nodes is referred to as an associative network. Information contained in the concept node is latent, or outside of conscious awareness, until the concept node is activated. Once activation reaches a threshold value, then the information contained in the concept node will enter into conscious awareness. Activation of a concept node will also spread to other adjacent nodes with which the concept node is linked. The level of activation diminishes as the process of "spreading activation" continues. This process results in priming of interconnected concept nodes.

Several theories have integrated emotional experience into a network model. Lang (1977) proposed a network model called the bio-informational theory to explain the organization of fear-related information. According to the bio-informational theory, emotional information is stored in memory within an interconnected network of propositional phrases (Lang, 1977; Lang, Kozak, Miller, Levin, & McLean, 1980). Propositional networks can be either highly organized and "tight" or less organized and "diffuse" (Lang, 1985). Emotional arousal activates the network of emotion-related meaning propositions, stimulus propositions, and response propositions. Meaning propositions store semantic information. Stimulus propositions represent characteristics of the emotional stimuli, and response propositions represent

characteristics of behaviors associated with the emotion. Response propositions associated with emotional activation can be verbal, motor, psychophysical, or perceptual (Lang, 1979). By including perceptual responses within the realm of response propositions, the bio-informational theory also presented a theory of how emotion affects information processing.

Bower (1981, 1987) also outlined a network theory of emotion, which proposed that semantic memory networks are related to emotional activity and cognitive processing of emotional information. According to Bower's theory, emotions are represented by nodes within networks, and are associated with a specific pattern of spreading activation. Therefore, a dominant mood state will prime concept nodes linked in memory with that mood. It has also been suggested that the network theory could be extended to explain effects of trait emotions as well as mood states. Specifically, Eysenck and Mogg (1992) suggested that individuals high in trait anxiety should demonstrate more links and stronger links between the anxiety node and the nodes congruent with anxiety, than individuals low in trait anxiety.

It has been predicted based on Bower's network theory that emotion influences cognitive processing. Some research has supported mood-state dependent retrieval associated with experimentally induced positive or negative moods (Bower, 1981). However, these findings have been difficult to replicate (Bower, 1987). Considerable research has supported mood-congruent attentional biases in anxiety and recall biases in depression in studies with patients diagnosed with emotional disorders (Williams et al., 1997). The network model also implies that emotional arousal will affect "top-down" cognitive processes, because emotional activation primes mood-congruent categories in memory, which subsequently influence interpretative processes (Bower, 1981). This prediction has been supported by mood-congruent effects on social judgments (Forgas

& Bower, 1987; Forgas, Bower, & Krantz, 1984) and self-efficacy judgments (Kavanaugh & Bower, 1985).

Test-Anxiety

The goal of this study was to illustrate cognitive associative networks related to anxiety. This was accomplished using the Pathfinder methodology. However, pilot work suggested that it would be difficult to illustrate cognitive networks using stimuli associated with generalized anxiety (i.e., social and physical threat words), because most people associate these words with negative emotions. Therefore, this study instead focused on cognitive structures associated with a situation-specific anxiety called test anxiety. It is necessary to review the test anxiety literature in order to provide a background in which to integrate network theory and formulate relevant hypotheses.

Test Anxiety: Theoretical Overview. Test anxiety results from evaluative concerns prompted by performance situations. Contemporary society is permeated with situations in which skills and competencies are evaluated. Research suggests test anxiety can adversely affect performance (Hembree, 1988), and so test anxiety can have significant real-life consequences. Because test-taking is an integral part of the academic process, test anxiety is especially salient for students. It has been estimated that approximately 10 million students experience test anxiety at precollege levels (Hill & Wigfield, 1984). Test anxiety is also a pervasive problem at the university level (Spielberger, Anton, & Bedell, 1976). For example, undergraduate students report "academic issues" as their most frequent worry (Borkovec, Robinson, Pruzinsky, & DePree, 1983).

Several theories have attempted to outline the relationship between test anxiety and performance. Mandler and S. Sarason (1952) developed the first test anxiety theory, which suggested that testing situations stimulated emotional arousal called an anxiety drive. This drive results in either an increase of task-relevant or task-irrelevant

responses. It was proposed that for people with low test anxiety, the drive results in task-relevant responses, which facilitate completion of the task and improve performance. However, for individuals with high test anxiety, the drive results in task-irrelevant responses, which detract from completion of the task and cause performance decrements (S. Sarason, Mandler, & Craighill, 1952).

The transactional model of test anxiety (Spielberger 1966, 1975; Spielberger & Vagg, 1995) differentiated test anxiety into trait and state dimensions. State test anxiety is the transitory emotional reaction experienced in response to the evaluative (testing) situation, which results in increased physiological and cognitive arousal. The intensity of a state test anxiety reaction depends upon the cognitive interpretation of threat associated with the situation. Trait test anxiety is a relatively stable personality characteristic of interpreting stimuli associated with evaluative situations as threatening. Therefore, an interaction effect occurs between trait and state test anxiety. According to the transactional model, individuals who are high in trait test anxiety will respond to evaluative situations with more intense state-trait anxiety reactions. Because of this interactive process, test anxiety is viewed as a situation-specific anxiety trait (Spielberger, Gonzales, Taylor, Algaze, & Anton, 1978).

Spielberger's model of test anxiety is consistent with the more general cognitive theories of emotion reviewed earlier. For example, it has been proposed that the intense state test anxiety reactions experienced by individuals who are high in trait test anxiety include activation of cognitive memory structures, which precipitate task-irrelevant cognitions and subsequently impair performance (Spielberger & Vagg, 1995). A similar process is proposed by the cognitive-attentional theory of test anxiety (Wine, 1980). The cognitive-attentional theory of test anxiety suggests that individuals experiencing high trait-state test anxiety reactions are distracted by task-irrelevant

thoughts, which impair performance by interfering with the task-relevant thoughts and behaviors. Therefore, the current zeitgeist in the field of test anxiety emphasizes cognitive variables.

Test Anxiety: Worry and Emotionality. In contrast to Mandler and S. Sarason (1952) who originally conceptualized test anxiety as a unitary drive associated with emotional arousal, the transactional and the cognitive-attentional models also integrate cognitive mediators into their theories. This dual-dimensional view of test anxiety was first advocated by Liebert and Morris (1967), who proposed that test anxiety is comprised of both worry and emotionality. Worry is the cognitive component of test anxiety, which includes rumination of evaluative concerns and negative self-statements regarding abilities. Emotionality refers to the perception of physiological arousal. Factor analytic studies lend support to test anxiety as a multi-dimensional construct (Benson & Tippetts, 1990; Schwarzer, 1984; Spielberger, 1980; Spielberger et al., 1978).

The independence of worry and emotionality is also supported by experimental research. For example, worry and emotionality are stimulated by different environmental cues. Worry increases in response to evaluative threat while emotionality increases in response to physical threats of shock (Morris & Liebert, 1973). In addition worry, but not emotionality, increases with task difficulty (Morris & Liebert, 1969). The worry and emotionality components of test anxiety are also associated with different patterns of activation, depending upon temporal proximity to the testing situation (Spiegler, Morris, & Liebert, 1968). Worry scores are stable from at least five days prior through the time period immediately after an exam. However, emotionality scores increase during the five preceding days of the exam, and then decrease dramatically immediately after the exam. Perhaps most importantly from a clinical perspective, research has consistently demonstrated that the worry component

has a stronger negative correlation with performance expectancies (Doctor & Altman, 1969; Morris & Liebert, 1970; Spiegler, et al., 1968) and is more closely associated with actual performance decrements than emotionality (Deffenbacher, 1980; Morris & Liebert, 1969; Morris & Liebert, 1970; Tryon, 1980).

Test Anxiety: Self-Evaluations. According to cognitive theories of test anxiety, negative self-evaluations about abilities may be the stimuli which prompt worries in testing situations (Flett & Blankstein, 1994). In fact, it has been found that individuals high in trait test anxiety usually have negative self-concepts. For example, individuals high in trait test anxiety use more negative adjectives (Flett & Blankstein, 1994; I. G. Sarason & Harmatz, 1965) and less positive adjectives (Flett & Blankstein, 1994) when describing themselves than do individuals low in trait test anxiety. In addition, measures of test anxiety are negatively correlated with measures of self-concept and self-esteem (Bandalos, Yates, & Thorndike-Christ 1995; Flett & Blankstein, 1994; Hembree, 1988). It has been suggested that test anxiety is more ego-involving than other types of anxiety due to expectations that a negative outcome reflects on enduring aspects of the self (Flett & Blankstein, 1994). In fact, individuals high in trait test anxiety have a tendency to attribute failure outcomes to internal causes (Doris & S. Sarason, 1955; Goldberg, 1983 as cited in I. G. Sarason, 1986).

Mueller and Thompson (1984) proposed that individuals high in trait test anxiety have incorporated themes of failure into the stable cognitive structures representing their self-schema. Negative self-efficacy evaluations while anticipating or participating in performance situations is a common theme in test anxiety theory. Research investigating thought content has found that participants high in test anxiety frequently have negative thoughts about their perceived abilities while in testing situations (Blankstein, Toner, & Flett, 1989; Zatz & Chassin, 1983, 1985). In addition,

the relationship between negative self-efficacy and the worry component of test anxiety was supported through structural equation modeling (Bandalos et al., 1995).

Cognitive Processing and Test Anxiety

As mentioned previously, hypotheses in this study were derived from network theories of emotion. These theories have several overlapping features. First each postulates an organized cognitive structure associated with emotion. In addition, each theory predicts information processing effects associated with emotional activation of cognitive structures. Based on this model, it would be predicted that both trait and state test anxiety (Spielberger, 1966) bias cognitive processing for information related to testing situations. Research which investigates the independent and interactive effects of trait and state test anxiety on cognitive processing of test-related information is reviewed below. Specifically, the effect of test anxiety on attention, interpretation, predictions of subjective risk, and memory will be reviewed.

Attentional Bias. Because each person has a limited capacity cognitive system, it is necessary to focus attentional resources onto the most salient environmental stimuli. As mentioned previously, it has been proposed that one function of anxiety is to alert individuals to cues which indicate danger. However, maladaptive hypervigilance to threat cues is a factor associated with high trait anxiety and clinical anxiety disorders (Williams et al., 1997). In the case of test anxiety, attentional bias would be directed toward information related to testing situations, and cues representing threats to self-esteem.

The dot-probe technique is a popular method of investigating attentional bias. In the dot probe methodology two words appear on a screen, one above the other. Research participants are instructed to attend to the word on top, and ignore the word on the bottom of the screen. One of the words on the screen is replaced by a dot, to

which the participant is instructed to respond as quickly as possible. The dot-probe technique is the preferred technique for investigating attentional bias, because as the dependent variable is response time to a neutral stimulus, this method controls for the effects of a negative response bias (MacLeod, Mathews, & Tata, 1986).

MacLeod and Mathews (1988) investigated mood-congruent attentional bias effects with participants scoring high in trait anxiety using the dot-probe methodology under conditions of low state test anxiety (12 weeks before an exam) and high state test anxiety (1 week before an exam). Results indicated there was an interactive effect of trait and state test anxiety for attentional bias toward threatening exam-related words. When state test anxiety was low, neither group showed evidence of attentional bias for exam-related words. However, when state test anxiety was high, participants in the high trait anxiety group exhibited significantly faster probe detection latencies when the probe replaced an exam-related threat word, and participants in the low trait anxiety group exhibited significantly slower probe-detection reaction times when the probe replaced an exam-related threat word. The authors concluded from this pattern of results that participants in the high trait anxiety group allocated attention toward exam-related threat words, and participants in the low trait anxiety group allocated attention away from threat words. A similar pattern of attentional bias for emotionally threatening cues has also been demonstrated using a dot-probe task with high test anxious children (Vasey, El-Hag, & Daleiden, 1996).

Attentional bias in anxiety has also been investigated using the emotional Stroop procedure. In the classic Stroop task (Stroop, 1935), color words are presented to the research participant in different colors of ink, and the research participant is instructed to name the color of the ink. It has been found that research participants take longer to respond when the letters spell a color name that is incongruent with the color in which the word is printed. This effect is attributed to interference with color naming from

attentional resources being directed toward cognitive processing of the written word. Studies of cognitive processing related to emotion utilize a modification of this method which is called the "emotional Stroop." In the emotional Stroop task, words with emotional valence are presented in different colors. It is hypothesized that when the written word is salient to the research participant, cognitive processing of the word will be facilitated, leading to an interference effect in the color-naming task. Interference in Stroop methodologies with anxious research participants on anxious words has been repeatedly demonstrated (Williams, Mathews, & MacLeod, 1996).

In an early report, it was found that students who were anticipating exams demonstrated an attentional bias on the emotional Stroop task toward exam-related words, and the effect was strongest for those students reporting high levels of state anxiety (Ray, 1979). MacLeod and Rutherford (1992) also investigated attentional bias using the emotional Stroop task. Research participants high and low in trait anxiety completed the experimental task during a period of high state test anxiety (one week before an exam period) and low state test anxiety (6 weeks after an exam period). The experimental stimuli presented during the Stroop were either exam-related or not exam-related words, and either threat-related or nonthreat-related words. In addition, each of these stimuli was presented under masked (below conscious perceptual awareness) and unmasked (above conscious perceptual awareness) conditions. Results indicated an interactive effect of trait and state anxiety in the masked condition only. Under conditions of low state anxiety, there were no differences between the groups on color naming. However, under conditions of high state anxiety, the participants in the high, but not the low, test anxiety group demonstrated slower color-naming latencies for threatening words.

Mogg, Mathews, Bird, and Macgregor-Morris (1990) examined the interactive effects of trait anxiety and state test anxiety on attentional bias using both the emotional

Stroop and dot-probe methodologies. Research participants were medical students who scored in the upper or lower 20th percentile on a measure of trait anxiety. The testing manipulation in this study was a difficult anagram task under either high stress (given "ego-involving" instructions and false negative feedback) or low stress (given "reassuring" instructions and false positive feedback). Findings of the emotional Stroop and dot-probe tasks indicated that state stress had an effect on attention. The attentional bias toward threatening information was specific to exam-related words in the Stroop task, but not specific to exam-related words in the dot-probe task. Interestingly, covariance analysis revealed that the effect of an exam-stress manipulation was independent of state anxiety scores. The authors concluded that stress as induced in an artificial experimental manipulation may affect attentional processes irrespective of trait anxiety status or mood state. However, when stress is prolonged, such as in anticipation of "real-life" exams, it was proposed that the cognitive ruminations preceding the exam may prime the relevant cognitive structures in order to provide state-trait interaction effects.

Interpretation Bias. Humans constantly impose meaning on the world. According to the cognitive theories of emotion, interpretative processes can be biased by emotional activation of cognitive structures. Specifically, it has been proposed that anxiety is associated with threatening interpretations of ambiguous situations. Research has generally supported this hypothesis with research participants who score high on trait measures of anxiety, as well as research participants who are diagnosed with anxiety disorders (Williams et al., 1997). It would be predicted based on the cognitive models of emotion that research participants high in test anxiety, and/or experiencing high state test anxiety reactions, would make biased interpretations of ambiguous exam-related information.

Calvo, Eysenck, and Estevaz (1994) used a lexical decision task to investigate interpretation bias associated with test anxiety. Participants were selected based on either high or low scores on a trait measure of test anxiety. State anxiety was induced in all participants using a performance task which involved both ego-involving instructions and false failure feedback. The experimental task involved ambiguous sentences followed by a lexical decision task that provided a continuation to the scenario. The disambiguated continuation was either threatening or nonthreatening. It was found that participants who were high in trait test anxiety and under performance stress were faster to make lexical decisions for threatening rather than nonthreatening words, and slower to reject a non-word that resembled a threatening word. Findings suggested some specificity for biased interpretation of ego-involving scenarios versus physically threatening scenarios.

Calvo, Eysenck, and Costillo (1997) analyzed reading times associated with processing of ambiguous sentences and disambiguating conclusions using a moving window procedure. Research participants were selected based on scores from a standardized measure of trait test anxiety. In addition, all participants received ego-involving instructions at the beginning of the task in order to activate state test anxiety. Results indicated faster reading times for participants in the high trait test anxiety group for information that was congruent with a negative interpretation, and slower reading times for interpretations that were incongruent with a negative interpretation. Again the interpretation bias effect was stronger for ego-threat information than for physical threat or nonthreat conditions. In related research, Calvo and Costillo (1997) determined that the interpretation bias associated with test anxiety was specific for ego-threatening meanings. In addition, this study included both high and low state test anxiety conditions. Because attentional bias effects were only found in conditions of high state

anxiety, the authors concluded that both stable cognitive structures, and current activation of cognitive structures by negative mood state, are necessary conditions for the interpretation bias effect in test anxiety.

Prediction Bias. In general, research participants who score high on trait test anxiety measures have negative expectations for the future. It has been found that worry associated with test anxiety is positively correlated with measures of pessimism (Flett & Blankstein, 1994; Topman, Kleijn, van der Ploeg, & Masset, 1992). In addition, within test taking situations research participants scoring high on test anxiety are more likely to expect failure outcomes than research participants scoring low on test anxiety, even when actual performance scores are controlled using covariance analysis (Mandler & S. Sarason, 1953). Butler and Mathews (1987) investigated probability ratings for future events in university students who scored high or low on trait anxiety during either low state test anxiety (rated one month before an exam) or high state test anxiety (rated one day before an exam). Findings indicated a main effect of exam proximity, with participants making more negative predictions for future events as the exam approached. In addition, there was a state-trait interaction effect. While participants in both the high and low trait anxiety groups increased probability ratings for negative exam-related outcomes as the exam approached, only research participants in the high trait anxiety group increased probability ratings for nonexam-related self-referent negative events. The authors interpreted these results based on Tversky and Kahneman's (1974) availability theory, and proposed that when state anxiety interacts with cognitive structures representing threat, anxious memories become more accessible, therefore increasing probability estimates.

Memory Bias. Network theories of emotion suggest that memory is biased for information that is congruent with current mood states (Bower, 1981, 1987). Memory bias associated with depression has been frequently supported (Blaney, 1986).

However, evidence of a memory bias for threatening information associated with anxiety has been mostly equivocal (Eysenck & Mogg, 1992). It has been suggested that while depression is associated with cognitive elaboration which enhances a memory bias for depressive information, anxiety is associated with attentional bias and subsequent cognitive avoidance of threatening information (Williams, Watts, MacLeod, & Mathews, 1988; Williams, et al., 1997). This distinct pattern of cognitive processing associated with anxiety does not facilitate recall for threatening information on direct explicit tests of memory; however, memory bias for threatening stimuli has been found on implicit test of memory (Williams et al., 1997). A memory test is explicit if the individual is asked to recall or recognize a previously learned stimulus, thereby specifically and directly utilizing the memory system. An implicit memory test occurs when there is evidence of priming effects for information learned previously; however, these tests are made without direct reference to the information or utilization of the memory system.

Mueller (1980) reviewed literature which suggests that in general, test anxiety adversely affects memory. However, very little research has been conducted on the effect of test anxiety on memory for emotionally valenced stimuli. In addition, the research which has been conducted on this issue is contradictory. Some research has found that participants who are high in trait test anxiety recalled significantly more anxiety-related words than did participants low in trait test anxiety on an explicit memory task (Ingram, Kendall, Smith, Donnell, & Ronan, 1987). However, others have not found specific differences between high and low trait test anxious participants on recall for emotionally valenced (i.e., threatening) words in either explicit or implicit memory tasks (Mueller, Elser, & Rollack, 1993). As with research on memory bias in anxiety in general, no conclusions can yet be drawn about a memory bias for emotionally valenced information associated with test anxiety.

Pathfinder Methodology: Description

According to Wine (1980), "There is a need for measurement devices which provide us with more information with greater specificity regarding the cognitive strategies and structures and the contents of consciousness of high as well as low test anxious persons" (p. 354). Recently computer programs have been developed which may provide the methods necessary to graph cognitive structures. The Pathfinder methodology is a computer program which translates numerical similarity ratings of all pair-wise concepts in a data set into a visual representation of the associative network for those concepts (Schvaneveldt, 1990; Schvaneveldt, Dearholt, & Durso, 1988).

Networks are determined through an algorithm which takes into account the computed distance between two nodes (represented by r) and the maximum number of links set for the network (represented by q). The density of a network is minimized by using the following parameters: $r = \text{infinity}$ (the weight of the path is determined by the maximum weight associated with any link in the path) and $q = n-1$ (the number of links in the network can not exceed degrees of freedom). These parameters result in the simplest network, and contain only the most psychologically pertinent connections (Branaghan, 1990). However, it has also been suggested that analyses conducted with increased q values can be informative as well (Schvaneveldt, personal communication, November, 1997).

Graphical networks are composed of concept nodes connected by associative links. In addition to visual representations, Pathfinder provides quantitative data which elaborates on the structure of the network. For example, the number of links in a network can be calculated, which is a measure of network complexity. In addition, Pathfinder provides information about the strength of association between two concept nodes in a variable called a link-weight. However, caution must be taken in the

interpretation of link-weight data, because these are ordinal measures. In addition, although Pathfinder provides information about the strength of association between concept nodes, the direction of the association between concept nodes is not clear.

Pathfinder Methodology: Applications

It has been demonstrated that Pathfinder networks represent psychologically meaningful associations. For example, Pathfinder has been used to demonstrate differences in network organization between experts and novices. Schvaneveldt et al. (1985) categorized Air Force pilots and undergraduate pilot trainees with over 90% accuracy based on Pathfinder networks of words related to air-combat situations. Differences were also found in networks of computer programmers differing in levels of expertise (Cooke & Schvaneveldt, 1988). Pathfinder is also being used to investigate relationships between learning in classroom situations and achievement. It has been found that network structures for course-related information changed following instruction (Gonzalvo, Canas, & Bajo, 1994). In addition, high achieving students showed different semantic networks for classroom information than low achieving students (Wilson, 1994). Finally, performance in classroom exams can be predicted based on the similarity between knowledge networks generated by the student and instructor (Goldsmith, Johnson, & Acton, 1991).

The Pathfinder methodology is also beginning to be applied to issues relevant to clinical psychology. Specifically, Pathfinder has been used to investigate changes in semantic organization resulting from Alzheimer's disease. In these studies, it has been found that networks between patients diagnosed with Alzheimer's Disease are different from networks generated from ratings made by normal control participants (Chan, Butters, et al., 1995). In addition, semantic networks change as a result of progressing neurological damage associated with Alzheimer's disease (Chan, Butters, & Salmon,

1997), and specific characteristic of networks can predict the rate of future cognitive decline (Chan, Butters, Salmon, & McGuire, 1993; Chan, Salmon, Butters, & Johnson, 1995).

Finally, Pathfinder methodology has been applied to investigations of emotionally valenced information. Melton (1995) found that the cognitive networks of moderately depressed individuals contained more links connecting negatively valenced words, and fewer links connecting positively valenced words, with concept nodes representing the individual's self, life, and future than was found in the cognitive networks of persons with mild or minimal depression. In addition, it has also been found that the number of links connecting self-referent concept nodes with negative self-descriptor words was positively correlated with a measure of depression (Mascaro & Geer, 1999). Geer (1996) compared males and females on semantic network organization for words related to sexuality. Findings suggested that male and female networks were more similar to networks from members of the same gender than the opposite gender. In addition there were gender differences found in the number of links between and within content categories, and the number of links associated with individual words. Network differences were consistent with gender stereotypes. Similarly, differences in network structures have been found between males and females for words related to intimacy (Rabalais & Geer, 1996), and between heterosexuals and homosexuals on words related to sexuality (Manguno-Mire & Geer, 1997). Associations between sex-related words and negatively valenced words also vary as a function of sexual inhibition (Smith et al., 1996). These findings support the use of Pathfinder with emotionally valenced information.

As mentioned previously, to date no published research has applied the Pathfinder methodology to investigations of anxiety. However, there is some data to suggest that ratings for semantic associations will change as a result of state anxiety.

Alexander and Husek (1962) developed a measure of situational anxiety based on semantic associations called the anxiety differential. The rationale for this assessment measure was stated as follows: "among the changes produced by anxiety states are changes in cognition, that is changes in the meanings of various events, persons, objects, and ideas" (p. 326). In a validation study, more changes in semantic association ratings were found following a stressful mood induction (watching a film on surgery) than after a neutral mood induction (watching a travel film). Therefore, there are differences in associative relationships as rated by the individuals in high and low state anxiety conditions.

There is also some support that associative networks differ for individuals high and low in trait anxiety. Pilot research was conducted using Pathfinder to illustrate associative networks of anxiety-related words. Specifically, stimuli used in pilot research was representative of three categories: physical threat (attack, injury, murder, assault), social threat (criticize, mocked, ridicule, humiliate), and negative emotional states (anxiety, worry, panic, nervous). Pearson-product correlational analysis indicated a significant correlation between trait anxiety and the number of links in networks associating these words ($p < .05$). This finding suggests that trait anxiety is associated with more complex and tightly connected networks for anxiety-related information.

Pathfinder Methodology: Validation Using Measures of Memory

It is proposed that Pathfinder-generated networks reflect structural aspects of mental models, such as memory organization (Schvaneveldt et al., 1989). Therefore, a validity test for Pathfinder is to demonstrate that associations in networks generated using the Pathfinder algorithm can predict recall of the same information. Cooke, Durso, and Schvaneveldt (1986) compared serial recall for lists of words that were associated together by Pathfinder with lists of words which were not. Research participants were presented with lists of 13 words, one at a time, and later asked to

recall all words on the list in the order of presentation. The experiment continued until all words were recalled correctly. Findings indicated that lists consisting of words which were linked together by Pathfinder were learned more quickly than the control list. Branaghan (1990) investigated the relationship between Pathfinder organization and memory in a paired-associate recall task. A series of word-pairs were presented to participants. Then participants were provided with one word and asked to indicate the corresponding word. This process continued until all word-pairs were recalled correctly. As predicted, pairs of words linked by the Pathfinder algorithm were learned more quickly than randomly selected word-pairs.

Another test for the validity of Pathfinder is to compare proximities between concept nodes determined by Pathfinder with proximities between the same concepts as determined from a previously validated measure of memory organization. Cooke et al. (1986) accomplished this goal by comparing proximities from networks generated by Pathfinder with proximities from clustering of items in a free-recall task. In this study, research participants were presented with a randomly ordered list of 13 items. Following presentation of the list, participants were asked to recall the list in any order. Recall proximities were calculated using a variation of a previously validated technique for extracting proximity data from clustering in free-recall (Friendly, 1977). Recall proximities were compared to proximities generated from an average Pathfinder network of the same concepts rated by a different sample of research participants. It was found that both the original self-report similarity ratings and Pathfinder associations predicted free-recall order. It has been well established that words that are similar will tend to be clustered together in free recall (e.g., Bousfield, 1953). However, the correlation between Pathfinder generated and free-recall generated proximities remained significant even with the variance contributed by self-report

similarity ratings partialled out of the statistical analysis. This finding suggests that the Pathfinder analysis provides psychologically meaningful information relevant to memory organization that is not accounted for purely by the similarity ratings.

Study Rationale

It has been suggested that people who are anxious have highly organized cognitive networks of information related to their primary current concern which, when activated, influences cognitive processing. Based on a review of the test anxiety literature, it is likely that cognitive structures associated with test anxiety include information related to testing situations, poor self-efficacy, and catastrophizing thoughts over the high probability of failure. It is hypothesized that when exam stress produces a state test anxiety reaction, the network associated with trait test anxiety is activated, thereby influencing cognitive processing for test related information. This theory has been supported indirectly with research investigating the effect of trait and state test anxiety on cognitive processing for information related to exams (e.g., Butler & Mathews, 1987; Calvo & Costillo, 1997; MacLeod & Mathews, 1988; MacLeod & Rutherford, 1992). However, to date there has been no direct evidence to establish the existence of different cognitive networks associated with high versus low test anxiety, or direct tests for relationships between emotional networks and measures of information processing. This may be due to the difficulties inherent in measuring and quantifying unobservable cognitive system organization. However, it is suggested here that the Pathfinder methodology may be applied to illustrate semantic network organization associated with test anxiety. This study attempted to demonstrate the validity of Pathfinder networks as a measure of memory organization. This was accomplished through correlational analyses, comparing network structure as determined by Pathfinder and memory organization as determined by clustering of

information in a free-recall task. Therefore, the goal of this study was to use the Pathfinder methodology to provide a direct test of predictions generated from cognitive theories of anxiety. This goal was accomplished in two separate studies.

Research Design: Study Number One

The purpose of study number one was to illustrate effects of trait and state test anxiety on semantic network organization for information related to test performance situations. The study employed a 2 X 2 X 3 repeated measures design. The two-level independent factor was Trait Test Anxiety (high versus low). The two-level repeated measures factor was State Test Anxiety (high versus low). The three-level repeated measures factor was Word Category (testing situations, positive performance evaluation, negative performance evaluation). Words related to testing situations were included as stimulus cues for similarity ratings with words which are hypothesized to be associated with test anxiety. Worries reported by individuals experiencing test anxiety are related to performance concerns (Flett & Blankstein, 1994). Therefore, words representative of performance evaluation (i.e., evaluation of test self-efficacy and/or test performance-outcome) were included in the present study. Both positively and negatively valenced words from this category were included. In conclusion, in study number one, Pathfinder networks of words from three content categories (testing situations, positive performance evaluation, negative performance evaluation) were compared for research participants scoring high and low on trait test anxiety in both high and low state test anxiety conditions.

Hypotheses: Study Number One

Hypotheses in study number one were made within the framework of network theory. Because no research has directly investigated the nature of semantic networks

related to anxiety, specific hypotheses were derived from theory and empirical evidence in other research areas, including the test anxiety and cognitive science literatures.

Hypothesis 1. Similarity Scores. Pathfinder provides an index of the similarity between two networks. This index is roughly representative of the number of links shared between two networks, and ranges from 0 to 1. Because there is no research to suggest that activation of the network (i.e., state anxiety) affects how similar one network is to another, similarity scores were only compared along the trait test anxiety variable (low versus high). It was predicted that networks generated from research participants who are classified in the same trait test anxiety group would be more similar than networks generated from research participants who are classified in different trait test anxiety groups. This hypothesis was derived from previous research which found that semantic networks for emotional information were more similar when compared within than between groups of research participants who vary on the primary emotional characteristic represented in the network (Geer, 1996).

Hypothesis 2. Link Weights of Test-Related Words With Negative Performance Evaluation Words. Link weights are a measure of associative strength. However, because link weights are measured on an ordinal scale, it was necessary to investigate this variable using a nonparametric statistical analysis. Link weights were only compared within-subjects across the state test anxiety variable (low versus high). It has been found that both high and low trait anxious research participants make more negative predictions about their test performance with closer proximity to the exam (high state test anxiety condition) than when the time of the exam is farther away (low state test anxiety condition) (Butler & Mathews, 1987). It was hypothesized based on the network model of emotion that these observed changes in test performance predictions (i.e., increased probability rating of a negative performance-outcome) reflect changes in the activation level of an associative network which relates these

concepts together (i.e., tests and negative performance evaluation). Therefore, it was predicted that there would be a greater increase in the strength of association as measured by link-weights connecting test-related words with negative performance evaluation words than would be expected by chance.

Hypothesis 3. Number of Links Within the Test-Related Content Category. The number of links within a category is a quantitative index of the complexity of organization for a category, and of the centrality of the category to the network. Analyses of the number of links within the test-related category was conducted across both the trait and state test anxiety variables. Three predictions were made: 3a) It was predicted that there would be a main effect of trait test anxiety, with participants in the high trait test anxiety group reporting more links within the test-related category than participants in the low-trait test anxiety group, 3b) It was predicted that there would be a main effect of state test anxiety, with participants in the high state test anxiety group reporting more links within the test-related category than participants in the low state test anxiety group, and 3c) It was predicted that there would be an interactive effect of trait and state test anxiety, with state anxiety producing a greater increase in links within the test-related category for participants in the high trait test anxiety group than participants in the low trait test anxiety group. These hypotheses were derived from the cognitive science literature, which suggests that attentional bias for test-related information increases in periods of high trait anxiety (MacLeod & Mathews, 1988) and state anxiety (Ray, 1979). This research indirectly supports the hypothesis that words related to testing-situations become more salient as a function of both trait and state test anxiety. The prediction of an interactive effect of trait and state test anxiety was derived from Spielberger's (1966) transactional model of test anxiety.

Hypothesis 4. Number of Links Within the Negative Performance Evaluation

Content Category. The number of links within a category is a quantitative index of the complexity of organization within the category, and the centrality of the category to the network. Analyses of the number of links within the negative performance evaluation content category was conducted across both the trait and state test anxiety variables. The following predictions were made: 4a) It was predicted that there would be a main effect of trait test anxiety, with participants in the high trait test anxiety group reporting more links within the negative performance evaluation category than participants in the low trait test anxiety group, 4b) It was predicted that there would be a main effect of state test anxiety, with participants in the high state test anxiety group reporting more links within the negative performance evaluation category than participants in the low state test anxiety group, and 4c) It was predicted that there would be an interactive effect of trait and state test anxiety, with state test anxiety producing a greater increase in links within the negative performance evaluation category for participants in the high trait test anxiety group than participants in the low trait test anxiety group. These predictions were derived from the test anxiety literature which suggests that preoccupations with poor performance in evaluative (i.e., testing) situations is a central aspect of the construct test anxiety (see I. G. Sarason, 1980 for a review). The prediction of an interactive effect of trait and state test anxiety was derived from Spielberger's (1966) transactional theory of test anxiety.

Hypothesis 5. Number of Links Between the Test-Related and Negative

Performance Evaluation Categories. The number of links between categories is a quantitative measure of the degree of relatedness. Analyses of the number of links between the test-related and negative performance evaluation categories were conducted across both the trait and state test anxiety variables. The following predictions were made: 5a). It was predicted that there would be a main effect of trait

test anxiety, with participants in the high trait test anxiety group having significantly more links connecting the test-related category and the negative performance evaluation category than the participants in the low trait test anxiety group, 5b). It was predicted that there would be a main effect of state test anxiety, with participants in the high state test anxiety group having more links connecting the test-related category and the negative performance evaluation category than participants in the low state test anxiety group, and 5c). It was predicted that there would be an interaction of trait and state test anxiety, with participants in the high trait test anxiety group having a greater increase in the number of links connecting the test-related category and the negative performance evaluation category from the low to high state test anxiety conditions than would occur for participants in the low trait test anxiety group. These predictions were derived from the test anxiety literature and cognitive science literatures which suggests that trait anxiety (Mandler & S. Sarason, 1953) and state anxiety (Butler & Mathews, 1987) are associated with negative predictions about test performance. Again the prediction of an interactive effect of trait and state test anxiety was derived from Spielberger's (1966) transactional theory of test anxiety.

Hypothesis 6. Number of Links Between the Test-Related and Positive Performance Evaluation Categories. The number of links between categories is a quantitative measures of the degree of relatedness. Analyses of the number of links between the test-related and positive performance evaluation categories were conducted across both the trait and state test anxiety variables. The following two predictions were made: 6a) It was predicted that there would be a main effect of trait test anxiety, with participants in the low trait test anxiety group having more links connecting the test-related category and the positive performance evaluation category than participants in the high trait test anxiety group, and 6b) It was predicted that there would be a main

effect of state test anxiety, with participants in the low state test anxiety group having more links connecting the test-related category and the positive performance evaluation category than participants in the high state test anxiety group. These predictions were also derived from the test anxiety and cognitive science literatures, which suggest that trait anxiety (Mandler & S. Sarason, 1953) and state anxiety (Butler & Mathews, 1987) are associated with negative predictions about test performance. In addition, there is evidence from the test anxiety literature that students who score high in trait test anxiety report fewer positive statements about their abilities than participants low in trait anxiety (Flett & Blankstein, 1994).

Research Design: Study Number Two

The purpose of study number two was to test the hypothesis that Pathfinder-generated associative networks for information related to test anxiety could predict recall proximity. This study employed a 2 X 2 repeated measures design. The two-level independent factor was Trait Test Anxiety (high versus low) and the two-level repeated measures factor was Experimental Method (Recall versus Pathfinder). In addition, Pathfinder can generate an average network for any given group. Proximities from the average networks generated in study number one for the High-Trait-Low-State and Low-Trait-Low-State test anxiety groups were also employed in study number two for correlational comparisons. The stimuli described for study number one were also used in study number two. Specific hypotheses for study number two are outlined below.

Hypotheses: Study Number Two

The hypotheses in study number two were also made within the framework of network theory. Semantic networks are models of human associative memory (Anderson & Bower, 1973; Collins & Loftus, 1975). If the networks generated by Pathfinder are valid representations of cognitive associative networks of test anxiety-

related information, then the proximities in the Pathfinder generated networks should correlate with clustering of information in a free-recall task.

Hypothesis 1. Within-Subject Correlations. It was predicted that there would be a significant correlation between the associative strength of word-pairs as determined by Pathfinder and the recall proximity of the word-pairs. This hypothesis was derived from previous validation research on Pathfinder (Cooke et al., 1986).

Hypothesis 2. Between-Subject Correlations. There were two predictions about correlations made between-subject groups: 2a) It was predicted that there would be a significant correlation between the associative strength of word-pairs in the average Pathfinder network generated in study number one for the High Trait-Low State test anxiety group, and recall proximity for the word-pairs in study number two for participants in the high trait test anxiety group, and 2b) It was predicted that there would be a significant correlation between the associative strength of word-pairs in the average Pathfinder network generated in study number one for the Low Trait-Low State test anxiety group, and recall proximity in study number two for participants in the low trait test anxiety group. These hypotheses were also derived from previous validation research on Pathfinder (Cooke et al., 1986).

Hypothesis 3. Comparing Within and Between-Subject Correlations. Statistically, within-subject comparisons are stronger tests because there is less variance in comparisons. Therefore, it was predicted that the within-subject correlations would be higher than the between-subject correlations.

Method: Study Number One

Participants

Participants were undergraduate students attending a large southern university, who received extra credit for participation. The sample was divided into a high trait test anxiety group and a low trait test anxiety group using T-scores from a standardized measure of trait test anxiety. A frequency analysis of scores from 91 students who completed the study was used to determine cut-off scores for the high and low trait test anxiety groups (upper and lower 30th percentile respectively). The cut-off for selection into the high trait test anxiety group was a T-score of 53 or greater, and the cut-off for selection into the low trait test anxiety group was a T-score of 42 or lower. The final sample consisted of 28 participants in the high trait test anxiety group and 25 in the low trait test anxiety group. It should be noted that a power analysis indicated that 25 participants per group were necessary in order to detect an effect size of .85 with .80 power at .05 alpha level. Demographic information for both groups is presented in Table 1. The groups did not differ on age, gender, ethnicity, or year in college. Both groups were composed primarily of Caucasian females, who were young adults and freshmen in college.

Procedure

Data collection occurred in two phases. Phase one took place during the first week of the semester, which was considered the low-state test anxiety time period. In phase one, participants were recruited during class, and students who chose to participate were given a packet of questionnaires to complete contained in a large manila envelope. This packet included an informed consent form, an instructions sheet, a state measure of test anxiety, a trait measure of test anxiety, a demographic questionnaire, a questionnaire regarding their appraisal of the first test in the class, a debriefing form, and a specially designed word ratings questionnaire. The instructions

Table 1
Demographic Characteristics by Group

Characteristic		Group		Statistical Test
		High Trait (n = 28)	Low Trait (n = 25)	
Age				
Mean (SD)		18.57 (.96)	18.76 (1.33)	$t(51) = -.60$
Range		18-22	18-22	
Gender				
Male		10 (36%)	7 (28%)	$X^2(1, N = 53) = .36$
Female		18 (64%)	18 (72%)	
Ethnicity				
Caucasian		23 (82%)	22 (88%)	$X^2(1, N = 53) = .35$
Noncaucasian		5 (18%)	3 (12%)	
Year				
Freshman		25 (89%)	19 (76%)	$X^2(1, N = 53) = 1.65$
Upperclassman		3 (11%)	6 (24%)	
<u>Note.</u> All tests nonsignificant at $p < .05$.				

sheet was always the top sheet in the packet followed by the informed consent form. The debriefing form was always the last page of the packet. The remaining questionnaires were administered in random order.

No identifying information was contained on the packet or questionnaires, except the informed consent form, on which the participant consented to the study with his or her signature. Questionnaires in the screening packet were coded with a subject number. A master list of subject names corresponding with subject numbers was made in order to correspond data collected at phase one with data collected at phase two. The master subject list was destroyed following phase two of the study.

Students were instructed to complete the packets in order, replace the questionnaires in the envelope, and return the envelope within the next two regularly scheduled class periods. Upon returning the packet, participants received two points of extra credit equivalent to 1 hour of study participation. A total of 185 packets were distributed during phase one of the study, and 162 packets were completed. This constitutes a return rate of 88%.

Phase two of the study took place one week before the first regularly scheduled exam in the class, which was considered the high state test anxiety time period. It should be noted that previous research examining state levels of exam stress have demonstrated effects of state anxiety on cognitive processing within one week's time of the exam (MacLeod & Mathews, 1988; MacLeod & Rutherford, 1992). Participants were recruited from the same psychology class as in phase one of the study. Packets contained an informed consent form, an instructions sheet, a state measure of test anxiety, a questionnaire regarding their appraisal of the first test in the class, a debriefing form, and specially designed word ratings questionnaire. Once again the instructions sheet was always the top sheet in the packet followed by the informed consent form. The debriefing form was always the last page of the packet. The

remaining questionnaires were administered in random order. Participants were instructed to complete the questionnaires in order, replace the questionnaires into the packet, and return the packet at the next regularly scheduled class period. There were five days between the day of packet distribution and the day of packet return. Participants were asked to complete the packet on the day prior to the exam or the day of the exam in order to increase the likelihood of high state exam stress. A total of 151 packets were distributed for phase two of the study and 126 were completed. This constitutes a return rate of 83%. Participants received two points of extra credit for completing phase two.

Stimuli

Word selection is one of the most important tasks in a study involving Pathfinder (Geer, 1996). It is important that the words are representative of the psychological domains of interest, in order to test specific hypotheses. Initially the words selected for inclusion in this study were representative of five content categories: test-related, positive self-efficacy, negative self-efficacy, positive test performance-outcome, and negative test performance-outcome. In pilot research, 38 words were selected as representative of these categories. Most of the pilot words were chosen from "examination-related" words used in previous research on test anxiety and cognitive processing (MacLeod & Mathews, 1988; MacLeod & Rutherford, 1992). Please note that the research cited above was conducted with British students, and there are some variations in "examination-related" colloquial language between British and American students. Therefore, additional pilot words were added, which were judged by the author to be relevant to the content domains as they are applied to the American population participating in the current research.

In a pilot study, 46 undergraduate psychology students categorized the list of 38 words into five content areas: testing situations, positive self-efficacy, negative self-

efficacy, positive test performance-outcome, and negative test performance-outcome. Students could also indicate if the word was not applicable to any of the categories. Frequency count analysis indicated only moderate reliability, and it was not possible to select three words representative of each category which were classified consistently by at least 80% of the population. Therefore, it was decided to conduct the study using three content categories instead of five in order to increase reliability. In another pilot study, a new sample of 181 undergraduate psychology students categorized the list of 38 words into three content areas: testing situations, positive performance evaluation, and negative performance evaluation. Students were instructed that "evaluation" in this study referred to words related to test self-efficacy (or ability) and/or test performance-outcome. Once again students could indicate if the word was not applicable to any of the categories. The four words most representative of the three categories, as evidenced by the highest level of interrater agreement by undergraduates ($M = 90.97$), were selected for the study. The stimulus words are presented in Appendix A.

Instruments

The Test Anxiety Inventory (TAI). The Test Anxiety Inventory (TAI) is a measure of trait test anxiety, which contains worry and emotionality subscales (Spielberger et al., 1978). The TAI contains 20 items rated on a five point Likert scale (1 = almost never to 4 = almost always). The TAI yields a total score as well as worry and emotionality subscale scores. The factor structure of the TAI has been confirmed in research in both the United States and abroad (Benson & Tippetts, 1990; Spielberger, 1980; Swarzer, 1984). The TAI has good test-retest reliability for up to one month ($>.80$), and excellent internal consistency for the total scale ($>.90$) (Spielberger, 1980). Concurrent validity was demonstrated with moderate to high positive correlations

between the total score from the TAI with other measures of both state and trait test anxiety (range .69 to .82) (Spielberger, 1980).

The Worry-Emotionality Questionnaire (WEQ). The Worry-Emotionality Questionnaire (WEQ) (Liebert & Morris, 1967; Morris, Davis, & Hutchings, 1981) is a measure of state levels of test anxiety. The WEQ contains 10 items, 5 of which measure worry and 5 of which measure emotionality. Each item is rated on a five point scale (1 = This statement does not describe my present condition to 5 = The condition is very strong; the statement describes my present condition very well). The subscales were constructed using factor analysis, and items were judged with 100% interrater agreement for inclusion on their respective subscales (Morris et al., 1981). Internal consistency for the WEQ subscales is .81 for the worry subscale and .86 for the emotionality subscale (Morris et al., 1981).

Test Expectancy Questionnaire. This questionnaire gathers information about the participant's expected performance-outcome of the exam. Based on formats used in previous test anxiety research (e.g., Doctor & Altman, 1969; Liebert & Morris, 1967), participants rated their performance expectancy on an 11 point probability scale (0 = definitely won't do as well on the test as I hoped to 1.0 = definitely will do as well on the test as I hoped). In addition, research participants reported the grade they expected to earn on the exam.

The Word Ratings Form. The word ratings form was constructed from listing 66 word-pairs presenting all possible pair-wise relations between the 12 words described above. In order to rule out the possibility of order effects, two different questionnaires were constructed by putting all the word-pairs in a different randomized order, with the limitation that the same between-categories rating would not appear more than twice in a row. In addition, the position of the item in each pair was counter-balanced across forms. This design resulted in 4 different word-rating forms. The format of the word-

rating form followed previous Pathfinder research (e.g., Manguno-Mire & Geer, 1997). For each word-pair, participants rated the relatedness of the words on a 9 point scale (1 = highly unrelated to 9 = highly related). Participants were instructed to indicate the number that best represented how much the words in each pair were related. Participants were also instructed to rate the words based on their first impression, and not to change any responses once a response was made. An example of the word-rating form is presented in Appendix B.

Demographic Questionnaire. This questionnaire simply asked the participant to provide information regarding his or her age, gender, ethnicity, year in college, and native language (see Appendix C).

Results: Study Number One

Manipulation Check

In the present study students were selected into groups based on trait test anxiety scores. As expected, the TAI scores for the two groups differed significantly [$t(32) = 16.16, p < .001$], with the participants in the high trait test anxiety group ($M = 61.36, SD = 6.67$) scoring significantly higher on the TAI than the participants in the low trait test anxiety group ($M = 40.04, SD = 1.95$). In the present study, exam proximity was used to manipulate state test anxiety. In order to assess if this manipulation was successful in changing state test anxiety, a 2 X 2 repeated measures Analysis of Variance (ANOVA) was conducted using a General Linear Model (GLM) program. The GLM program was used to analyze all subsequent ANOVAs as well. In the current analysis, the two-level independent variable was Trait Test Anxiety and the two-level repeated measures variable was State Test Anxiety. The dependent variable was WEQ score. There was a significant main effect of Trait Test Anxiety [$F(1, 51) = 54.91, p < .001$], with the participants in the high trait test anxiety group ($M = 28.29, SD = 7.41$) scoring significantly higher on the WEQ than participants in the low trait test anxiety group ($M = 16.04, SD = 3.86$). There was also a significant main effect of State Test Anxiety [$F(1, 51) = 6.84, p < .02$], with participants in the high state test anxiety group ($M = 23.68, SD = 8.95$) scoring significantly higher on the WEQ than participants in the low state test anxiety group ($M = 21.34, SD = 9.48$). The Trait Test Anxiety X State Test Anxiety interaction on WEQ scores, however, was not significant [$F(1, 51) = 2.36, p > .05$]. Means and standard deviations for WEQ scores are presented in Table 2.

Test Expectancy Questionnaire

Predicted differences in cognitive structures due to both trait and state test anxiety were based in part on evidence that predictions about exam performance are

Table 2
Means and Standard Deviations of Manipulation Check Variables

Measure	State Anxiety	
	High	Low
WEQ Scores	High Trait	28.79 (8.15)
	Low Trait	27.79 (8.42)
Test Performance Expectancy Ratings	High Trait	17.96 (5.87)
	Low Trait	14.12 (3.53)
Percentile Grade Expectancy Ratings	High Trait	6.29 (2.58)
	Low Trait	7.07 (1.87)
Percentile Grade Expectancy Ratings	High Trait	83.29 (7.26)
	Low Trait	86.18 (6.98)
Percentile Grade Expectancy Ratings	High Trait	87.24 (6.01)
	Low Trait	89.92 (6.01)

affected by these variables. Therefore, it was of interest to investigate if expectancies for performance on the exam differed based on trait and state test anxiety status. A 2 X 2 repeated measures ANOVA was conducted with the two-level independent variable Trait Test Anxiety and the two-level repeated measures variable State Test Anxiety. The dependent variable was the test performance expectancy rating. Two participants in the high trait test anxiety group and one student in the low trait test anxiety group failed to complete a test performance expectancy rating during at least one of the administrations, therefore these participants were excluded from the current analysis. There was a significant main effect of State Test Anxiety on expectancy ratings [$F(1, 47) = 13.61, p < .001$], with participants in the high state test anxiety condition rating their performance expectancies ($M = 6.67, SD = 2.23$) significantly lower than participants in the low state test anxiety condition ($M = 7.52, SD = 1.63$). The main effect of Trait Test Anxiety on expectancy approached statistical significance [$F(1, 47) = 3.62, p = .063$], with participants in the high trait test anxiety group ($M = 6.62, SD = 2.01$) rating expectancies lower than the participants in the low trait test anxiety group ($M = 7.54, SD = 1.28$). There was no significant Trait Test Anxiety X State Test Anxiety interaction [$F(1, 47) = .02, p > .05$] on test performance expectancy ratings (see Table 2).

A second 2 X 2 repeated measures ANOVA was conducted with the two-level independent variable Trait Test Anxiety, and the two-level repeated measures variable State Test Anxiety. The dependent variable was the self-reported expected percentile grade on the first exam. There was a main effect of group [$F(1, 51) = 5.52, p < .05$], with the high trait test anxiety group ($M = 84.73, SD = 6.42$) reporting lower grade expectancies than the low trait test anxiety group ($M = 88.58, SD = 5.38$). There was also a main effect of State Test Anxiety [$F(1, 51) = 12.25, p < .001$], with the sample reporting lower grade expectancies during the high state test anxiety time period ($M =$

85.15, $SD = 6.93$) than the low state test anxiety period ($M = 87.94$, $SD = 6.74$). The Trait Test Anxiety X State Test Anxiety interaction; however, was not statistically significant [$F(1, 51) = .02$, $p > .05$]. Means and standard deviations for grade expectancy ratings are presented in Table 2.

Pathfinder Generated Networks (PFNETs)

As stated earlier, the hypotheses tested in this study revolve around Pathfinder analysis. The following is a description of the process used to extract data from the Pathfinder analysis. First word-pair ratings for each participant were entered into the Pathfinder program. As explained earlier, the Pathfinder algorithm uses two parameters to conduct its analyses. The parameters set by the experimenter for data analysis in the present study were $r = \text{infinity}$, which required only an ordinal rating scale, and $q = n-1$, which generated the simplest network. A Pathfinder generated network (PFNET) was established for each participant. PFNETs reduce proximity data into concept nodes connected by links. Each link is labeled with a link weight, which indicates the strength of the link in the network. Recently it has been suggested that decreasing the q -parameter may also create psychologically meaningful network structures (Schvaneveldt, personal communication, November, 1997). Therefore, in the present study all analyses were also conducted on networks derived using the parameter $q = 2$. This q -value created the most complex networks available with pathfinder (Durso & Coggins, 1990). However, altering the q -parameter did not significantly change the results of the study. Therefore, only analyses with the originally proposed parameter $q = n-1$ were presented. All analyses regarding pathfinder links were also rerun at $q = n-1$ using the following covariates: number of days prior to the exam that the questionnaire was completed and self-reported preparedness for the exam. Again; however, these analyses were not significantly different from analyses without covariates. Therefore, only the analyses without covariates were presented.

Data Analysis of Similarity Scores

Hypothesis one made predictions about the similarity of networks to one another. Pathfinder can generate similarity scores when comparing two networks. The similarity score ranges from 0 to 1, and represents a measure of the number of mutual links shared by the two networks. In order to test hypothesis one, a similarity score was computed for each participant's network compared to every other participant's network. Only data collected during the low state test anxiety phase of the study were analyzed, because there is no evidence to date on which to base predictions about the effect of state stress on similarity scores. Predicted differences of similarity scores were compared using the nonparametric Kruskal-Wallis One-Way Analysis of Variance, because the distribution of similarity scores is unknown. The means and standard deviations of similarity scores are presented in Table 3. Two separate similarity scores analyses were conducted. Comparison of the within-group High Trait-High Trait and the between-group High Trait-Low Trait similarity scores was statistically significant [$\chi^2 (1, N = 1077) = 26.62, p < .001$]. However, contrary to hypothesis one, examination of Table 3 indicates that this difference was due to a higher similarity score for the between-group High Trait-Low Trait than the within-group High Trait-High Trait scores. Comparison of the within-group Low Trait-Low Trait and the between-group High Trait-Low Trait similarity scores was also statistically significant [$\chi^2 (1, N = 1000) = 30.36, p < .001$]. Examination of Table 3 indicates that this difference was due to the expected higher similarity score for the within-group Low Trait-Low Trait than the between-group High Trait-Low Trait score.

Data Analysis of Link Weights

Hypothesis two made predictions about the change in the strength of association (link weights) between test-related words and negative performance evaluation words from the low state test anxiety to the high state test anxiety conditions. As mentioned

earlier, care must be taken in the analysis and interpretation of link-weight data, because these are ordinal data. Therefore, hypothesis number two was tested using the Wilcoxin matched-pairs signed-rank test. This test is the nonparametric statistic used when comparing two dependent samples. This test is more powerful than an alternative nonparametric test called the sign-test, because it takes into account the magnitude as well as the direction of the change in scores (Siegel, 1956). A Wilcoxin matched-pairs signed-rank test comparing predicted changes in the average link-weights for links connecting test-related words with negative performance evaluation words from the low state test anxiety and high state test anxiety conditions was not significant ($z = -.27$, $p > .05$), but the majority of changes were in the predicted direction.

Table 3
Means and Standard Deviations of Similarity Scores

Group	Similarity Score
High Trait-High Trait	.28 (.10)
Low Trait-Low Trait	.36 (.11)
High Trait-Low Trait	.32 (.10)

Note. Means are shown with standard deviations in parentheses.

Data Analysis of the Number of Links Within Each Category

Hypotheses three and four examined differences in the number of links within word categories. To test hypotheses three and four, first a 2 X 2 X 3 repeated measures ANOVA was conducted. In this analysis the two-level independent variable was Trait Test Anxiety, the two-level repeated measures variable was State Test Anxiety, and

the three-level repeated measures variable was Word Category. The dependent variable was the number of links for each participant within the word categories. There was a main effect of Word Category [$F(2,50) = 5.22, p < .01$], with more links reported within the positive performance evaluation category ($M = 3.92, SD = 1.12$) than the test-related ($M = 3.75, SD = 1.16$) or negative performance evaluation ($M = 3.43, SD = 1.29$) categories. There were no other significant main effects or interactions. Subsequent individual 2 X 2 repeated measures ANOVAs were computed for the test-related and negative performance evaluation categories. In these analyses the two-factor independent variable was Trait Test Anxiety, and the two-level repeated measures variable was State Test Anxiety. The dependent variable was the number of links for each participant within the word category of interest. There were no significant main effects of Trait Anxiety [$F(1, 51) = .04, p > .05$], or State Anxiety [$F(1, 51) = 1.64, p > .05$], or Trait Anxiety X State Anxiety interaction [$F(1, 51) = .52, p > .05$] for the number of links within the test-related word category. There were also no main effects of Trait Anxiety [$F(1, 51) = 2.38, p > .05$], or State Anxiety [$F(1, 51) = .06, p > .05$], or Trait Anxiety X State Anxiety interaction [$F(1, 51) = 1.60, p > .05$] for the number of links within the negative performance evaluation category. Means and standard deviations for the number of links within test-related and negative performance evaluation word categories is presented in Table 4, and indicate trends in the direction opposite of current hypotheses.

Data Analysis of the Number of Links Between Categories

Hypotheses five and six examined differences in the number of links between content categories. In testing hypotheses five and six, first a 2 X 2 X 3 repeated measures ANOVA was conducted. In this analysis the two-level independent variable was Trait Test Anxiety, the two-level repeated measures variable was State Test Anxiety, and the three-level repeated measures variable was Category Pair. The

Table 4
Means and Standard Deviations of the Number of Links Within Word Categories

Word Category		State Anxiety	
		High	Low
Test-Related	High Trait	3.50 (1.73)	3.93 (1.15)
	Low Trait	3.72 (1.43)	3.84 (1.21)
Negative Performance Evaluation	High Trait	3.29 (1.67)	3.07 (1.27)
	Low Trait	3.56 (1.61)	3.88 (1.36)

dependent variable was the number of links for each participant between each of the three word content categories. There was a significant main effect of Category Pair [$F(2, 50) = 18.71, p < .001$], with more links reported between the test-related and positive performance evaluation category ($M = 4.89, SD = 3.65$) than between the test-related and negative performance evaluation category ($M = 2.42, SD = 2.42$). There were no other significant main effects or interactions. Subsequent individual 2 X 2 repeated measures ANOVAs were computed for the number of links between the test-related and negative performance evaluation categories to test hypothesis five, and for the number of links between the test-related and positive evaluation categories to test hypothesis six. In these analyses the two-level independent variable was Trait Test Anxiety, and the two-level repeated measures variable was State Test Anxiety. The dependent variable was the number of links for each participant connecting the Category Pair of interest. There were no significant main effects of Trait Anxiety [$F(1, 51) = .00, p > .05$], or State Anxiety [$F(1, 51) = .44, p > .05$], or Trait Anxiety X State Anxiety interaction [$F(1, 51) = 2.35, p > .05$] for the number of links connecting test-related and negative performance evaluation word categories. There were also no significant main effects of Trait Anxiety [$F(1, 51) = .02, p > .05$], or State Anxiety [$F(1, 51) = .64, p > .05$], or Trait Anxiety X State Anxiety interaction [$F(1, 51) = .88, p > .05$] for the number of links connecting test-related and positive performance evaluation word categories. Means and standard deviations for these variables are presented in Table 5.

Additional analyses were conducted to assess the level of association between word categories by investigating the shortest distance (i.e., the least number of links) between any test word with any positive performance or negative performance evaluation word. In these analyses a smaller number indicates a stronger level of association between the word categories. Individual 2 X 2 repeated measures ANOVAs

Table 5

Means and Standard Deviations of the Number of Links Between Word Categories

Word Category Pair		State Anxiety	
		High	Low
Test Related-Negative Evaluation	High Trait	1.86 (1.99)	2.97 (3.44)
	Low Trait	2.64 (3.62)	2.20 (2.99)
Test Related-Positive Evaluation	High Trait	4.79 (4.41)	4.86 (4.31)
	Low Trait	5.48 (4.37)	4.44 (4.07)

were computed with the two-level independent variable Trait Test Anxiety and the two-level repeated measures variable State Test Anxiety. The dependent variable was the least number of links connecting any test-related word with any negative or positive performance evaluation word. There were no significant main effects of Trait Anxiety [$F(1, 47) = .65, p > .05$], or State Anxiety [$F(1, 47) = .03, p > .05$], or Trait Anxiety X State Anxiety interaction [$F(1, 47) = .03, p > .05$] for the least number of links connecting any test-related word with any negative performance evaluation word. There were also no significant main effects of Trait Anxiety [$F(1, 48) = .21, p > .05$] or State Anxiety [$F(1, 48) = .21, p > .05$] for the least number of links connecting any test-related word with any positive performance evaluation word. The Trait Anxiety X State Anxiety interaction approached statistical significance [$F(1, 48) = 3.77, p = .058$], with the least number of links between any test word and any positive performance evaluation word decreasing for the low trait test anxiety group with increased exam stress, and increasing for the high trait test anxiety group with increased exam stress. This finding suggests that there was a stronger relationship between test-related and positive performance evaluation words as exam stress increased for the low trait test anxiety group, but a weaker relationship between these word categories as exam stress increased for the high trait test anxiety group. Means and standard deviations for these variables are presented in Table 6. It should be noted that although the interaction effect approached statistical significance, the changes in mean link distances were very small.

Post-Hoc Analyses

Number of Links on Each Word. The number of links on individual words is a quantitative measure of the centrality of that word to the network. However, present theories are not sufficiently well developed to make predictions about the effect of trait and state test anxiety on the number of links for individual words, and so this effect was examined in exploratory post-hoc analyses. First a 2 X 2 X 12 repeated measures

Table 6
Means and Standard Deviations of the Least Number of Links
Between Word Categories

Word Category Pair		State Anxiety	
		High	Low
Test Related-Negative Evaluation	High Trait	1.24 (.52)	1.19 (.48)
	Low Trait	1.33 (.70)	1.32 (.75)
Test Related-Positive Evaluation	High Trait	1.08 (.27)	1.03(.19)
	Low Trait	1.00 (.00)	1.12 (.44)

ANOVA was conducted. In this analysis the two-level independent variable was Trait Test Anxiety, the two-level repeated measures variable was State Test Anxiety, and the twelve-level repeated measures variable was Individual Words. The dependent variable was the number of links for each participant on each word. There was a significant main effect of Individual Words [$F(11, 41) = 13.76, p < .001$], with the number of links reported on individual words ranging from the most for "test" ($M = 4.22, SD = 1.51$), to the least for "stupid" ($M = 2.36, SD = .98$). There were no other significant main effects or interactions. Subsequent individual 2 X 2 repeated measures ANOVAs were computed for each Word. In this analysis the two-factor independent variable was Trait Test Anxiety, and the two-level repeated measures variable was State Test Anxiety. The dependent variable was the number of links on each word. The results of the ANOVA analyses are presented in Table 7. Means and standard deviations are presented in Table 8.

Cumulative Number of Links in the Network. The cumulative number of links in a network is a quantitative measure of the richness and complexity of the network. However, it is also not possible to make specific a priori predictions about the effect of trait or state test anxiety on the cumulative number of links in the network in the present study. Therefore, an additional post-hoc exploratory analysis was conducted using a 2 X 2 repeated measures ANOVA. In this analysis the two-level independent variable was Trait Test Anxiety, and the two-level repeated measures variable was State Test Anxiety. The dependent variable was the cumulative number of links contained in each participant's network. There was no significant main effect of Trait Test Anxiety [$F(1, 51) = .38, p > .05$], or State Test Anxiety [$F(1, 51) = .04, p > .05$], and no significant Trait Test Anxiety X State Test Anxiety interaction [$F(1, 51) = .46, p > .05$]. The means and standard deviations for the cumulative number of links in the networks are presented in Table 9.

Table 7
Analysis of Variance of the Number of Links on Individual Words

Word	Source	df	E
Test	State Anxiety	1, 51	1.25
	Trait Anxiety	1, 51	.04
	State Anxiety X Trait Anxiety	1, 51	.53
Quiz	State Anxiety	1, 51	.42
	Trait Anxiety	1, 51	1.09
	State Anxiety X Trait Anxiety	1, 51	1.75
Finals	State Anxiety	1, 51	.07
	Trait Anxiety	1, 51	.34
	State Anxiety X Trait Anxiety	1, 51	1.93
Exam	State Anxiety	1, 51	.19
	Trait Anxiety	1, 51	.80
	State Anxiety X Trait Anxiety	1, 51	3.84
Capable	State Anxiety	1, 51	1.93
	Trait Anxiety	1, 51	.20
	State Anxiety X Trait Anxiety	1, 51	.53

(table 7 continued)

Skilled	State Anxiety	1, 51	.001
	Trait Anxiety	1, 51	.13
	State Anxiety X Trait Anxiety	1, 51	.63
Successful	State Anxiety	1, 51	.61
	Trait Anxiety	1, 51	.28
	State Anxiety X Trait Anxiety	1, 51	.09
Brilliant	State Anxiety	1, 51	5.33*
	Trait Anxiety	1, 51	.25
	State Anxiety X Trait Anxiety	1, 51	.04
Failure	State Anxiety	1, 51	.88
	Trait Anxiety	1, 51	.08
	State Anxiety X Trait Anxiety	1, 51	.35
Incompetent	State Anxiety	1, 51	.11
	Trait Anxiety	1, 51	.07
	State Anxiety X Trait Anxiety	1, 51	.24
Stupid	State Anxiety	1, 51	3.52
	Trait Anxiety	1, 51	.99
	State Anxiety X Trait Anxiety	1, 51	.01

(table 7 continued)

Unsuccessful	State Anxiety	1, 51	1.66
	Trait Anxiety	1, 51	.08
	State Anxiety X Trait Anxiety	1, 51	.003

Note. * $p < .05$.

Table 8
Means and Standard Deviations of the Number of Links on Individual Words

Word	State Anxiety	
	High	Low
Test	High Trait	3.89 (1.52)
	Low Trait	4.46 (2.17)
Quiz	High Trait	4.20 (1.94)
	Low Trait	3.04 (1.37)
Finals	High Trait	3.00 (1.98)
	Low Trait	2.48 (1.45)
Exam	High Trait	3.32 (1.67)
	Low Trait	3.86 (1.60)
	High Trait	4.00 (2.33)
	Low Trait	3.64 (1.78)
	High Trait	3.39 (1.59)
	Low Trait	4.14 (1.72)
	High Trait	4.36 (1.91)
	Low Trait	3.88 (2.09)

(table 8 continued)

Capable	High Trait	3.71 (2.31)	3.07 (1.84)
	Low Trait	3.68 (1.60)	3.48 (1.58)
Skilled	High Trait	3.14 (1.96)	3.36 (1.95)
	Low Trait	3.20 (1.41)	3.00 (1.66)
Successful	High Trait	4.25 (1.73)	3.89 (2.06)
	Low Trait	4.36 (1.93)	4.20 (1.78)
Brilliant	High Trait	3.50 (1.62)	2.97 (2.01)
	Low Trait	3.76 (1.61)	3.12 (1.83)
Failure	High Trait	2.61 (1.20)	2.96 (1.17)
	Low Trait	2.68 (1.31)	2.76 (1.16)
Incompetent	High Trait	2.64 (1.39)	2.43 (1.75)
	Low Trait	2.60 (1.38)	2.64 (1.35)

(table 8 continued)

Stupid	High Trait	2.43 (1.23)	2.04 (1.20)
	Low Trait	2.72 (1.37)	2.28 (1.28)
Unsuccessful	High Trait	2.79 (1.23)	3.18 (1.74)
	Low Trait	2.88 (1.30)	3.24 (1.51)

Table 9
Means and Standard Deviations of the Cumulative Number of Network Links

		State Anxiety	
		High	Low
Cumulative Number of Links	High Trait	19.39 (5.58)	19.86 (6.82)
	Low Trait	21.08 (7.81)	20.20 (7.62)

Discussion: Study Number One

This study was designed to explore the organization of cognitive networks related to test anxiety. The effect of both trait and state test anxiety was investigated. Predictions were based on network theory and the cognitive science literature.

From analysis of the manipulation checks it can be concluded that the participant groups were valid, with participants in the high trait test anxiety group reporting significantly more test anxiety and lower grade expectancies than participants in the low trait test anxiety group. In addition, there was a trend for participants in the high trait test anxiety group to predict poorer test performance than participants in the low trait test anxiety group. From the manipulation check analysis it can also be concluded that the state test anxiety manipulation was effective, with participants in the high state test anxiety group reporting more test anxiety, lower grade expectancies, and lower performance expectancies than participants in the low state test anxiety group. These findings are consistent with previous test anxiety research investigating the effect of trait and state test anxiety on test performance expectancies (e.g., Butler & Mathews, 1987; Hembree, 1988).

It should be noted that there were no significant interactions of trait test anxiety with state test anxiety on measures of state test anxiety or performance expectancies. In other words, both groups responded in equivalent ways to the exam-stress manipulation. This finding does not support Spielberger's interactive model, which suggests that high trait test anxious students will respond to an exam stressor with more intense state anxiety reactions than will low trait test anxious students (Spielberger et al., 1976). However, the current findings are consistent with previous research investigating relationships between trait anxiety and exam stress (e.g., Butler & Mathews, 1987; MacLeod & Mathews, 1988; MacLeod & Rutherford, 1992; Mogg et al., 1990).

Despite successful manipulation of trait and state test anxiety, neither independent variable exerted a significant main or interactive effect on cognitive network organization of test-related, positive performance evaluation, and negative performance evaluation words. There were no differences between the high and low trait or state test anxiety groups on any of the following dependent variables: the number of links within the test-related word category, the number of links within the negative performance evaluation word category, the number of links between the test-related and positive performance evaluation categories, the number of links between the test-related and negative performance evaluation categories, the number of links associated with individual words, or the cumulative number of links within networks. In addition, there was no effect of state test anxiety on change in link-weights for links connecting test-related and negative performance evaluation words.

Analysis of network similarity scores indicated that contrary to predictions made in hypothesis one, the high trait test anxiety networks were more similar to low trait test anxiety networks than to other high trait test anxiety networks. However, in support of hypothesis number one, low trait test anxiety networks were more similar to other low trait test anxiety networks than they were to high trait test anxiety networks. These findings indicate that there is considerable overlap between networks generated by high and low trait test anxiety participants. In addition, these findings indicate that there is likely more variability in the networks generated by high trait test anxiety participants than low trait test anxiety participants.

The comparability of high and low trait test anxiety networks was surprising given the extensive cognitive science literature supporting predictions of differences in cognitive networks between these two groups. Therefore, the possibility that this study contained insufficient power to indicate statistically significant results was considered; however, this is unlikely given that the number of participants included in the samples

met or exceeded the number that was suggested by a power analysis. The conclusion that statistical power was not a factor in generating negative findings in the present study is further supported by the replication of null results during post-hoc tests performed using a replication sample with the high ($n = 49$) and low ($n = 41$) trait test anxious participants from study number two of this report.

As mentioned previously, the selection of words in Pathfinder research is an integral part of the investigative process. In the present study, word selection was based on an extensive test anxiety literature which illustrates differences in self-efficacy related to testing situations for high and low trait test anxious participants (e.g., Bandalos et al., 1995; Blankstein et al., 1989; Hembree, 1988; Zatz & Chassin, 1983, 1985). However, it is still possible that different words would have been able to more accurately assess effects of trait and state test anxiety on cognitive networks. In order to rule out this hypothesis, a follow-up Pathfinder study was conducted. In the follow-up study 40 undergraduate students in psychology classes completed a Pathfinder task, the TAI, and the WEQ. The sample was predominantly Caucasian (75%) and female (82%), with a mean age of 20.70 ($SD = 4.35$) years. Words selected for inclusion in the Pathfinder networks were test-related words (test, exam, finals, midterm, quiz) and anxiety-related words (afraid, anxious, scared, worried, nervous). The category of anxiety-related words was selected based on Bower's (1981) theory which describes emotion nodes within the system, and pilot research which suggested that the number of links connecting negative emotional words with words related to current concerns was significantly correlated with trait anxiety (see introduction). However, neither trait test anxiety ($r = -.04$, $p > .05$) nor state test anxiety ($r = .06$, $p > .05$) was significantly correlated with the number of links in the network connecting test-related and anxiety-related words. In addition, neither trait test anxiety ($r = -.12$, $p > .05$) nor state test

anxiety ($r = .12$, $p > .05$) was significantly correlated with complexity of the network as measured by the cumulative number of links in the network.

It is possible that level of test anxiety did not affect networks of words chosen for inclusion to date, because most people, regardless of test anxiety level, associate test-taking with the potential for both positive and negative outcomes, and with anxiety to some degree. It is suggested that future research investigating cognitive networks associated with anxiety select more specific anxiety-related stimuli which would not generalize to the general population. For example, future research may investigate cognitive network organization associated with contamination fears in obsessive-compulsive disorder. Additional research with test anxious populations may also be explored with the inclusion of different word categories. As mentioned previously, high and low test anxious participants differ in level of test performance self-efficacy. Therefore, it may be essential to include a self-referent word category in the Pathfinder analysis in order to capture differences in cognitive networks between high and low test anxious participants. This hypothesis is supported by previous research with depressed participants, which found that level of depression was related to associative connections between self-referent words and depressive words (Mascaro & Geer, 1999; Melton, 1995). However, this hypothesis remains for further study with anxious participants.

Positive findings illustrating differences in Pathfinder networks associated with depression contrasted with null findings in the current study of anxiety-related networks may also reflect a true difference between these affective states. There is substantial evidence of differences in both cognitive content (e.g., Beck, Brown, Steer, Eidelson, & Riskind, 1987; Clark, Beck, & Stewart, 1990; Woody, Taylor, McLean, & Koch, 1998) and processing (Williams et al., 1997) associated with anxiety and depression. Specifically in terms of network theory, memory biases predicted by Bower's (1981)

model have been supported in samples of depressed participants, but have not been supported in anxiety (Teasdale & Barnard, 1993). Therefore, it may follow that the network model may apply to depression, but not to anxiety. Comparisons of cognitive networks associated with depression and anxiety represents another area requiring further study.

A final explanation for the null results in the present study lies within the validity of the Pathfinder method. Previous research has shown that Pathfinder successfully illustrates network organization related to knowledge acquisition and expertise (Cooke & Schvaneveldt, 1988; Gonzalvo et al., 1994; Schvaneveldt et al., 1985; Wilson, 1994), neuropsychological deterioration (Chan, Butters, et al., 1995; Chan, Butters, et al., 1997; Chan, Salmon, et al., 1995), and affectively-laden information (Geer, 1996; Manguno-Mire & Geer, 1997; Melton, 1995; Rabalais & Geer, 1996). The Pathfinder method has also been validated by demonstrating the association between Pathfinder organization and recall with affectively-neutral stimuli (Branaghan, 1990; Cooke et al., 1986). However, no Pathfinder memory research has been conducted to date with affectively-laden stimuli. This issue will be addressed in the second study of this report.

In conclusion, current results do not support the cognitive network theory of anxiety. While this theory had been supported indirectly with evidence of biased cognitive processing associated with anxiety (e.g., Butler & Mathews, 1987; MacLeod & Mathews, 1988; MacLeod & Rutherford, 1992), the same cognitive science literature has generated findings which can not be adequately explained by network theories (Teasdale & Barnard, 1993). Consequently, new, broader, and more elaborate theories of information processing in anxiety are being developed (e.g., Mathews & Mackintosh, 1998). Results of the current research support the continuation of these efforts.

Method: Study Number Two

Participants

Participants were 44 undergraduate psychology students, who attend a large southern university, and received extra credit for participation. The sample was divided into a high trait test anxiety group ($n = 21$) and a low trait test anxiety group ($n = 23$). Demographic information for both groups is presented in Table 10. The groups did not differ on age, gender, or year in college. A chi-square analysis of ethnicity was not possible due to one empty cell; however, inspection of Table 10 suggests there may be a difference in ethnicity between the groups. A point-biserial correlation which was used to investigate the relationship between ethnicity and the dependent variable of interest in the present study (i.e., z -transformed within-subject correlations between pathfinder word-pair distances and recall word-pair distances) was not statistically significant ($r_{pb} = -.05$, $p > .05$). This finding suggests that ethnicity was not a confound in the present study; therefore, ethnicity was not used as a covariate in analyses.

Procedure

Participant Selection Process. Screening with the TAI was completed by 297 students. Volunteers received one extra credit point for their participation in this part of the study. During the screening, participants also completed an informed consent form, on which they indicated if they wished to be contacted for participation in additional research provided that they qualified. Students were excluded at this phase if they indicated they did not wish to participate further ($n = 46$). T-scores from the standardized measure of trait test anxiety for the remaining 251 participants underwent a frequency analysis to determine cut-off scores for the high trait test anxiety group (upper 30th percentile of the sample) and low trait test anxiety group (lower 30th percentile of the sample). The cut-off for selection into the high trait test anxiety group ($n = 83$) was a T-score of 57 or greater, and the cut-off for selection into the low trait

Table 10
Demographic Characteristics by Group

Characteristic	Group		Statistical Test
	High Trait (n = 21)	Low Trait (n = 23)	
Age			
Mean (SD)	19.90 (3.58)	20.61 (3.70)	$t(42) = -.64$
Range	18 - 35	18 - 30	
Gender			
Male	7 (33%)	11 (48%)	$\chi^2(1, N = 44) = .95$
Female	14 (67%)	12 (52%)	
Ethnicity			
Caucasian	21 (100%)	18 (78%)	
Noncaucasian	0 (0%)	5 (22%)	
Year			
Freshman	15 (71%)	12 (52%)	$\chi^2(1, N = 44) = 1.72$
Upperclassman	6 (29%)	11 (48%)	
Note. All tests nonsignificant at $p < .05$.			

test anxiety group ($n = 77$) was a T-score of 43 or lower. Of these qualified participants, 49 participants in the high trait test anxiety group and 41 participants in the low trait test anxiety group completed the experimental portion of the study.

Additional inclusion criteria were developed in order to ensure validity of the recall data collected in the experimental session. The last four recall trials constituted the current data set, and only participants who recalled all 12 words on at least one of the last four recall trials were included in the final sample. Consequently, 43 participants were excluded due to missing data (26 in the high trait test anxiety group and 17 in the low trait test anxiety group). There were no differences between the groups on exclusion rates due to missing data [$\chi^2 (1, N = 90) = 1.66, p > .05$]. Three additional participants (two in the high trait test anxiety group and one in the low trait test anxiety group) were excluded because they indicated English was not their native language. Exclusion rates due to the English criteria were also comparable between the groups [$\chi^2 (1, N = 90) = .19, p > .05$]. The final sample consisted of 21 participants in the high trait test anxiety group and 23 participants in the low trait test anxiety group. A power analysis indicated that a sample size of 25 was necessary in order to detect a correlation of .397 as statistically significant with .80 power at .05 alpha two-tailed. However, it should be noted that in the present study, pathfinder-generated and recall-generated distances were correlated across 66 word-pairs. In other words, in the present study, the sample size was always $N = 66$, regardless of the number of participants who were included in the analyses. Therefore, increasing the number of participants in the study would not influence power of the correlational analysis.

Because increasing sample size may more accurately represent the true population mean of the Pathfinder-generated and Recall-generated networks, analyses were conducted with additional participants. First two participants in the high trait test

anxiety group and one participant in the low trait test anxiety group who met the recall data criteria but indicated that English was not their native language were included. In addition, the recall criteria was relaxed slightly to include three participants in the high trait test anxiety group and two participants in the low trait test anxiety group who recalled at least 11 words on at least three of the last four recall trials. Altering the inclusion criteria in this way resulted in 26 participants per group. Subsequent analyses did not consistently benefit from the inclusion of additional participants (e.g., one correlation became statistically significant and one correlation lost statistical significance); therefore, only results with the data meeting all inclusion criteria originally set forth in the study were reported.

Experimental Session. Participants who consented to continue in the study when contacted by phone completed an experimental session which involved two tasks: a recall task and a Pathfinder task. The recall task was always completed first. This standardized order was necessary in order to avoid contamination of the recall task by multiple exposure to the stimuli during the Pathfinder task. The within-subject design was chosen over a between-subjects design because it is a stronger test of effects. In addition, by always having the recall task completed first, between-subject comparisons without any confounding variables could also be made between recall-generated networks in study number two and Pathfinder-generated networks in the first phase of study number one.

During the recall task, participants were seated in front of a computer screen. The procedure used in this portion of the study was modeled after Cooke et al. (1986) with some modifications. First an experimenter read out loud the following instructions:

The first task is a memory task. You will see 12 words appear on the computer screen one at a time. The words will appear in the center of the screen where

you now see the row of plus signs. Please read each word to yourself silently as it appears on the screen, and do your best to remember the words. After all 12 words have been shown to you, a tone will sound, and the plus signs will appear on the screen again. At that point I will ask you to recall the words you have just seen. You may recall the words in any order. You will have one minute to write down as many words as you can remember. Please write one word per line, and write neatly if possible. After one minute you will hand me your paper and I'll ask you to start the next trial. You will do this several times before we are done. Do you have any questions?

The participant pressed the space-bar to begin the task. The 12 words used as stimuli in study number two were the same words as described in study number one. One word was shown at a time for 1.5 seconds. The words were presented in random order. The end of the word-list presentation was signaled by a 500 ms tone, and the participant was prompted by the experimenter to recall the words in any order. After one minute, the experimenter took the recall sheet from the participant and encouraged him or her to begin the next trial by pressing the space-bar. This procedure continued for 10 trials. Ten trials were chosen in response to pilot testing which indicated that participants were having difficulty recalling all the words with fewer trials. It should be noted that even with 10 trials, nearly half of the collected data was excluded because it still did not meet the minimal recall criteria set forth in the present study.

After the 10 word-presentation recall trials, the participants completed two recall trials without additional presentation of the words. These two trials were preceded by a non-evaluative interference task. The interference task was interjected in order to facilitate clustering of information in recall (e.g., Cooper & Monk, 1976). During the interference task, students were presented with a table of random numbers, and asked to cross-out every instance of a specified number. The choice of number was standardized for each trial. Numbers were used in order to avoid confounding of recall with verbal-linguistic information. It was stressed to the participants that their performance on the number task was not being evaluated in any way, so as not to

increase state anxiety. The interference task lasted for one minute before prompting by the experimenter to recall the words viewed previously. After two delayed recall trials, the participants completed the same interference task for 5 additional minutes before proceeding to the second experimental phase.

The second task was a Pathfinder word-rating task. This task was similar to the procedure used in study number one; however, in the present study the word ratings were completed using a computer. The first screen appearing on the computer presented instructions on how to complete the task. Next the participants were presented with the list of words used in the task. Finally, the computer presented the 66 word-pairs which represented every pair-wise combination of the 12 stimulus words described earlier. Word-pairs were presented one word-pair at a time, and in random order. Participants were asked to select a number from 1 to 9 (1 = highly unrelated to 9 = highly related) which indicated the degree of relatedness between the two concepts. Once ratings were made, participants were instructed to press the enter key, which prompted the next word-pair to appear. This process continued until all 66 ratings were completed.

The final task in study number two was completion of a state measure of test anxiety and a demographic questionnaire. These questionnaires were administered in random order. Once the questionnaires were finished, the participants read a debriefing statement and received two additional points of extra credit.

Instruments

The TAI, WEQ, and demographic questionnaire were described in study number one and were also used in study number two.

Results: Study Number Two

Test Anxiety Measures

In the present study students were selected into groups based on trait test anxiety scores. As expected, the TAI scores for the two groups differed significantly [$t(26) = 20.46, p < .001$], with the participants in the high trait test anxiety group ($M = 61.29, SD = 4.26$) scoring significantly higher on the TAI than the participants in the low trait test anxiety group ($M = 40.83, SD = 1.78$). State test anxiety was not an independent variable in the present study. The participants were recruited from the same classes and completed the study at varying times of the semester, so the existence of exam-stressors was likely distributed equally across the groups. However, state test anxiety as measured by the WEQ also differed significantly between the groups [$t(42) = 7.01, p < .001$], with the participants in the high trait test anxiety group ($M = 30.76, SD = 7.63$) scoring significantly higher on the WEQ than the participants in the low trait test anxiety group ($M = 17.13, SD = 5.13$). In order to be sure there was no influence of state test anxiety as a confound, WEQ scores were correlated with the dependent variable of interest in study number two (i.e., the z-transformed correlations between Pathfinder-generated distances and Recall-generated distance), and this correlation was not significant statistically ($r = -.12, p > .05$). Because state anxiety was not associated with the dependent variable of interest, WEQ scores were not controlled in subsequent statistical analyses.

Proximity Ratings

In order to test the hypotheses for study number two, it was necessary to generate proximity data from the two methods described earlier: Pathfinder and Recall. The process of extracting proximity data using these two methods is described below.

Pathfinder-Generated Proximities. As in study number one, the relatedness ratings for each participant were entered into a Pathfinder analysis. The computation of

PFNETs was analogous to that used in study number one. Once again the parameter set by the experimenter for data analysis was $r = \text{infinity}$ and $q = n-1$. Subsequent analyses altering the q -parameter were not performed in study number two, as this alteration did not significantly affect composition of networks in study number one. In addition, setting the same parameters kept consistency between analyses in the two studies. The proximity score (path length) provided by Pathfinder for each of the word-pairs generated in each participant's PFNET was the dependent variable of interest. Generation of proximity scores followed that used by Cooke et al. (1986) with one slight modification. The proximity scores were computed by summing the number of links in each internode path for each word-pair for each participant. Experts in the field of Pathfinder research have indicated that this measure is equivalent to the measure of summing the internode link weights used by Cooke et al. (Schvaneveldt, personal communication, December, 1998)

In addition to individual participant network proximities, in several cases proximities of average participant networks were used in data analysis. An average network was derived by Pathfinder for the high trait test anxiety group (see Figure 1) and low trait test anxiety group (see Figure 2) in study number two. In addition, average networks were derived for the High Trait-Low State test anxiety group (see Figure 3) and Low Trait-Low State test anxiety group (see Figure 4) in study number one. The proximity score (path length) for each of the word-pairs in these average networks was computed by summing the number of links in each internode path for each of the word-pairs.

Free-Recall Generated Proximities. The dependent variable of interest from the free-recall task was the proximity of word-pairs as recalled by participants. Friendly (1977) developed a technique which derives structural representations of memory from free-recall order. An adapted version of the Friendly (1977) technique has been used in

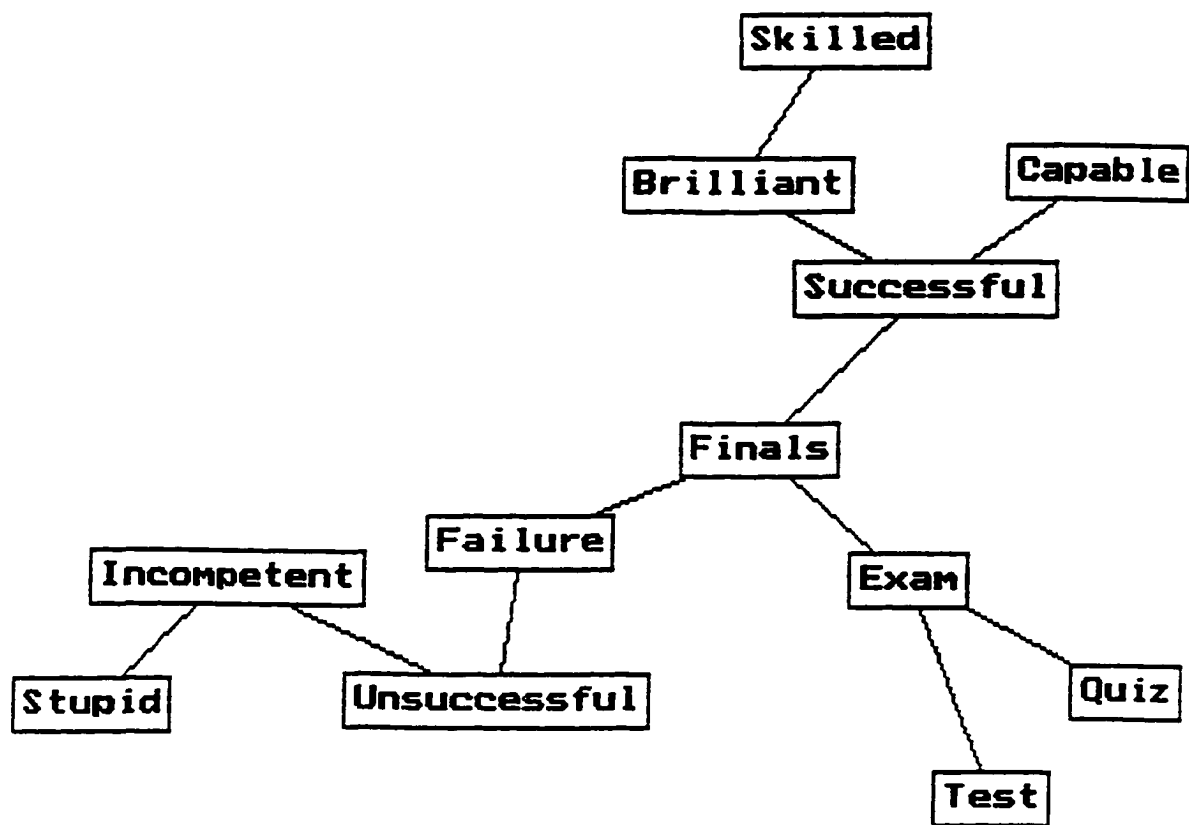


Figure 1
Average Pathfinder Network for the High Trait Test Anxiety Group
in Study Number Two

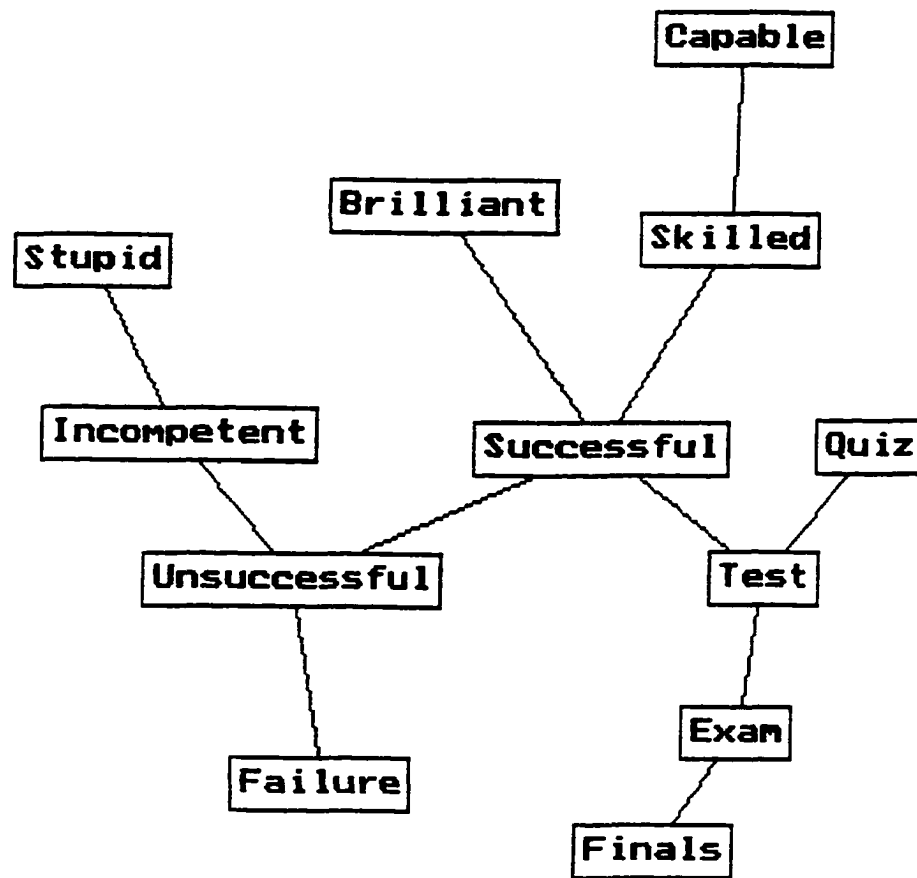


Figure 2
Average Pathfinder Network for the Low Trait Test Anxiety Group
in Study Number Two

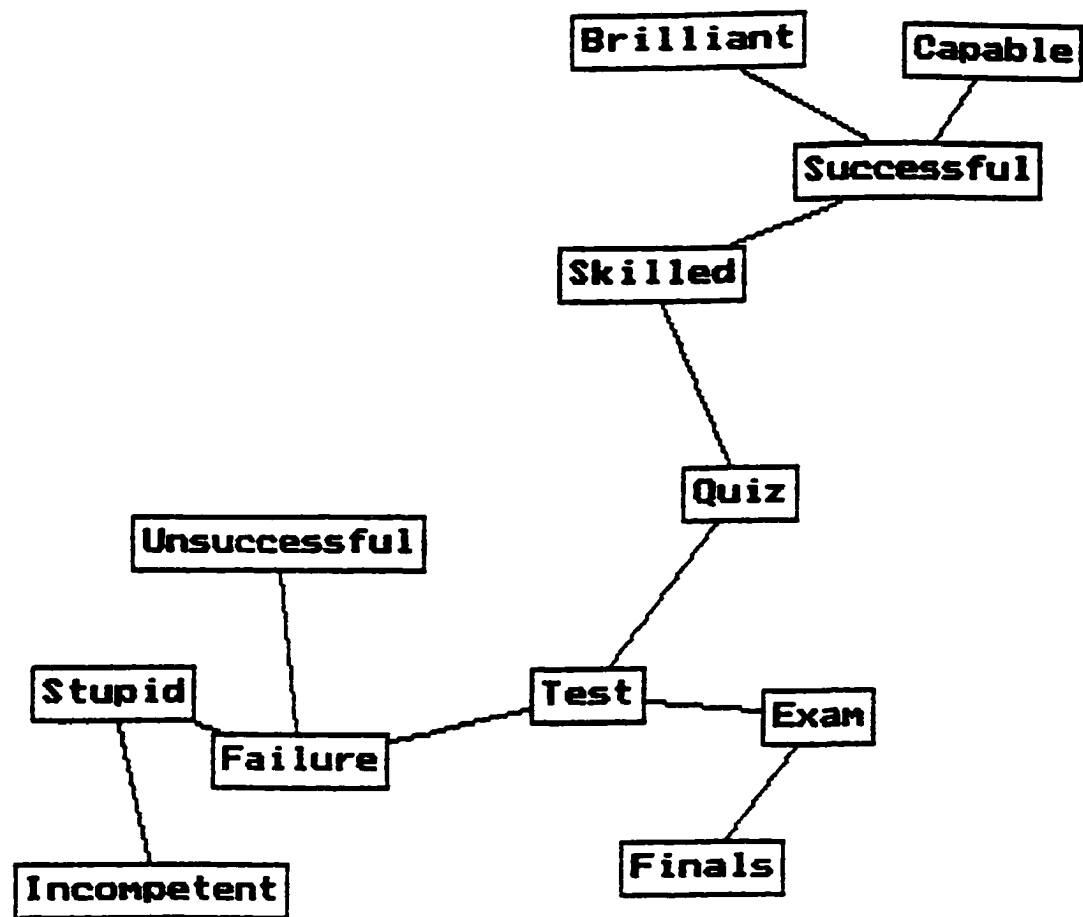


Figure 3
Average Pathfinder Network for the High Trait-Low State Test
Anxiety Group in Study Number One

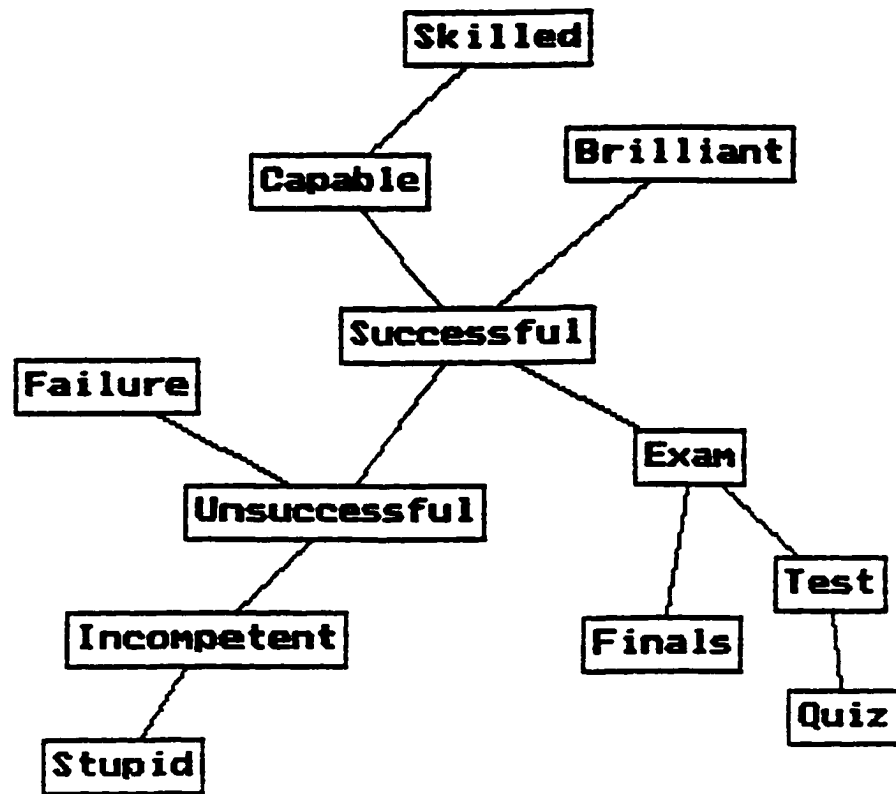


Figure 4
Average Pathfinder Network for the Low Trait-Low State Test
Anxiety Group in Study Number One

previous comparisons with Pathfinder (Cooke et al., 1986), and was also used in the present study. Each recall trial was conceptualized as a network, with adjacent words linked together. Figure 5 shows a randomly selected recall trial represented as a network. In this example, "test" was the first word recalled by the participant, "finals" the second, and so on. The proximity for each word-pair for each recall trial was determined by summing the number of intervening links between words on the recall list. For example, words recalled one after the other, such as "test" and "finals" in Figure 5, received a proximity of 1, or 1 link connecting them. The first and third words recalled, such as "test" and "exam" in Figure 5, received a proximity of 2: one link connecting the first with the second word ("test" with "finals"), and one link connecting the second with the third word ("finals" with "exam"). It is important to note that in this analysis a shorter distance, or a smaller number of links between words, represents a stronger level of association. After calculation of recall distances for each of the 66 word-pairs, the distance scores on the last four trials were averaged together. Therefore, each word-pair for each participant received an average recall distance over the last four trials.

Correlational Analyses

Correlational analyses were conducted to test the hypothesis that Pathfinder generated proximities predict clustering for information in memory as assessed in a free-recall task. These analyses attempted to validate Pathfinder by illustrating a significant relationship between Pathfinder output and a measure of cognitive processing which is believed to reflect the structure of information in memory.

Individual Pathfinder Network Proximities Correlated with Individual Recall Proximities. Correlations of Pathfinder-generated proximities with Recall-generated proximities across the 66 word-pairs were calculated for each participant. Participant network correlations were then subjected to Fischer's z -transformation. These z -

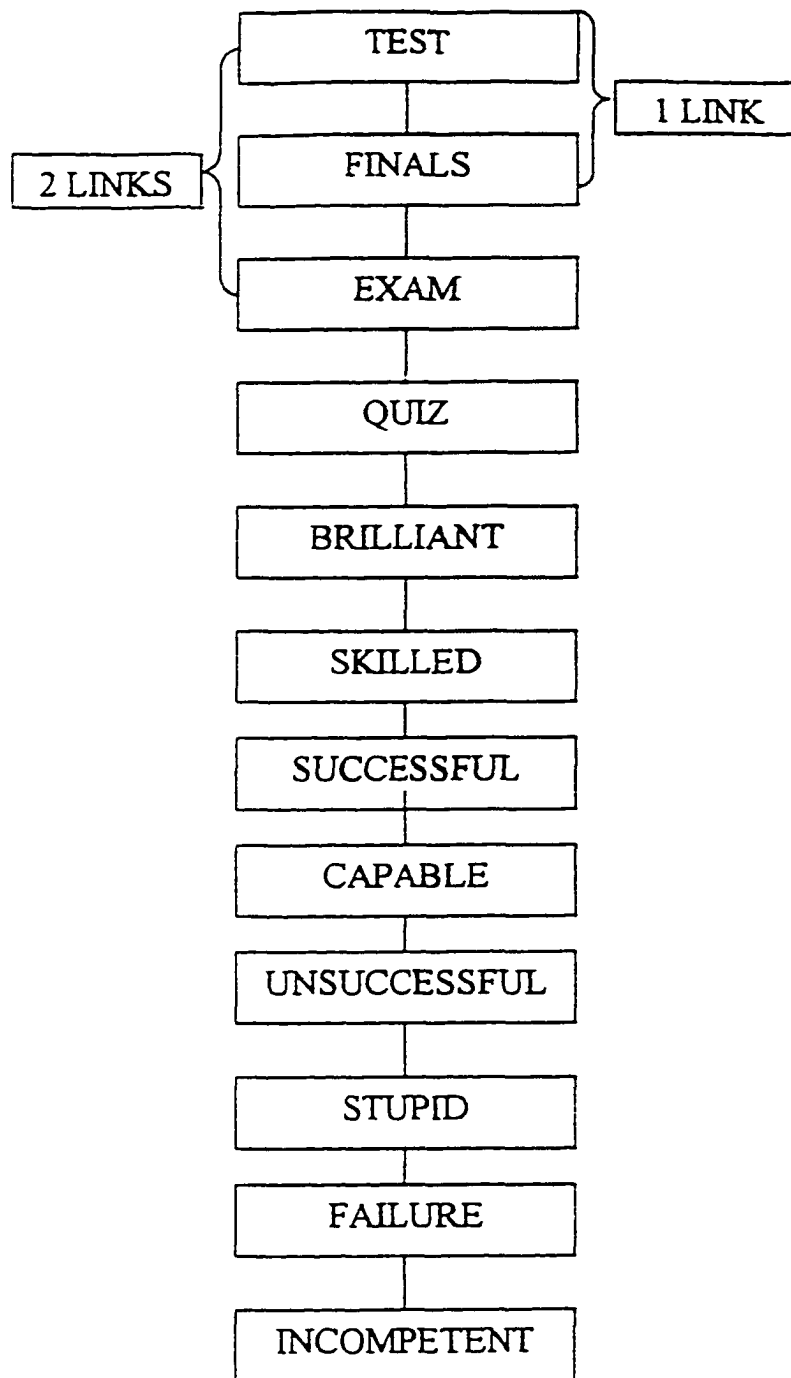


Figure 5
Randomly Selected Recall Trial Represented as an Associative Network

transformed correlations were used in analyses discussed previously in order to determine if certain participant variables (e.g., state test anxiety, ethnicity) were related to the association between Pathfinder and Recall-generated proximities. Z-transformed participant network correlations were also averaged together and transformed back to an r as one measure of association in the present study. Mean correlations were low for the entire participant sample ($r = .13$), the high trait test anxiety group ($r = .11$), and the low trait test anxiety group ($r = .15$). Mean correlations of the high and low trait test anxiety groups did not differ significantly ($z = .22, p > .05$). Although the mean correlations were small, chi-square analysis indicated that there were significantly more positive correlations than would be expected by chance [$\chi^2 (1, N = 44) = 11.00, p < .001$].

Average Pathfinder Network Proximities in Study Two Correlated With Average Recall Proximities in Study Two. An alternative method for calculation of correlations between Pathfinder-generated proximities and Recall-generated proximities which is more similar to the analyses reported by Cooke et al. (1986) was also conducted. In order to test hypothesis number one, the Pathfinder-generated proximities from the average Pathfinder network for the high trait test anxiety group and low trait test anxiety group in study number two were correlated with the average recall proximities for each respective group. These analyses were conducted once as bivariate analyses and once with the original Pathfinder computer ratings partialled out of the analysis (see Table 11). The partial correlations were performed in order to assess if Pathfinder generated networks were contributing to the correlation above influences of original computer ratings of relatedness. Findings suggested that while Pathfinder and Recall generated distances were significantly correlated for both the high and low trait test anxiety groups in the bivariate analyses, these correlations were

Table 11
Correlations of Average Pathfinder Network Proximities in Study Two With Average Recall Proximities in Study Two With and Without the Contribution of Original Pathfinder Ratings Controlled

Group	Bivariate Correlation	Partial Correlation
High Trait Test Anxiety	.29*	-.16
Low Trait Test Anxiety	.51***	.18

Note. * $p < .05$, *** $p < .001$.

no longer significant once the contribution of the original Pathfinder similarity ratings was controlled.

Average Pathfinder Network Proximities in Study One Correlated With Average Recall Proximities in Study Two. In order to test hypothesis number two, two between-subjects correlations were also computed between proximity scores generated from the average group networks in study number one and average proximity scores generated through the free-recall task in study number two: one for participants in the high-trait test anxiety group and one for participants in the low-trait test anxiety group. These analyses were also conducted as bivariate and partial correlations controlling for the original Pathfinder computer ratings (see Table 12). When using a between-subjects analysis, the Pathfinder and Recall generated distances were significantly correlated for the low-trait test anxiety group for both the bivariate and partial correlations. However, neither correlation was significant for the high trait test anxiety group.

Comparison of Within-Subject Correlations and Between-Subject Correlations. Finally, in order to test hypothesis number three, comparisons of within-subject and between-subject correlations of average Pathfinder-generated and average Recall-generated distances for the high and the low trait test anxiety groups were conducted. Contrary to predictions, within and between-subject correlations did not differ for either the high ($z = .92, p > .05$) or low ($z = .19, p > .05$) trait test anxiety groups. These findings suggest high comparability between the average cognitive networks generated in the first and second reports of this study for both the high and low trait test anxiety groups.

Table 12
Correlations of Average Pathfinder Network Proximities in Study One With Average Recall Proximities in Study Two With and Without the Contribution of Original Pathfinder Ratings Controlled

Group	Bivariate Correlation	Partial Correlation
High Trait Test Anxiety	.13	-.07
Low Trait Test Anxiety	.53***	.41***

Note. *** $p < .001$.

Discussion: Study Number Two

This study was designed to test the validity of the Pathfinder methodology by demonstrating an association between the cognitive networks generated by Pathfinder and cognitive networks derived from a measure which is believed to reflect the organization of information in memory (i.e., free-recall data). Such a relationship would indicate that Pathfinder not only pertains to theoretical frameworks, but is also associated with a measure of human behavior.

Mean correlations of individual participant Pathfinder networks with that same individual's recall data were low and did not differ between high and low trait test anxiety groups. This finding suggests that Pathfinder may not be a valid measure of cognitive network organization, at least when the unit of analysis is individual networks. However, previous Pathfinder research has generally conducted group analyses with averaged data, which reduces random error in the data set (e.g., Cooke & Schvaneveldt, 1988). Therefore, in the current study, correlational analyses were also conducted by first averaging data across participants for both Pathfinder and Recall data and then performing correlations. These correlations were conducted both as within-subject and between-subject analyses.

The within-subject analyses suggested that average Pathfinder networks were related to average recall data for both the high and low trait test anxiety groups. However, this association was due entirely to the contribution of original relatedness ratings. These findings are consistent with extensive cognitive psychology literature demonstrating a positive association between semantic relatedness and recall organization (e.g., Bousfield, 1953). However, the findings are problematic for the use of Pathfinder method even with group data, as they suggest that Pathfinder does not provide information about cognitive structure above that which can be assessed by investigating similarity ratings, at least when the correlations are conducted entirely

within-subject. Interestingly, when the same analysis was conducted between subjects (i.e., the average Pathfinder network of one group correlated with the average recall of another group), the Pathfinder algorithm did contribute significantly to the relationship with recall organization above that which was provided by the original similarity ratings alone. However, this effect was found only in the low trait test anxiety group. Positive relationships found in the low trait test anxiety group are consistent with Cooke et al. (1986), who also found average Pathfinder organization was significantly correlated with averaged free-recall organization between-subjects. The null results in the current study for the high trait test anxiety group, however, requires further exploration.

As mentioned in study number one, Pathfinder networks generated by the high trait test anxious participants appeared to be less stable than networks generated by low trait test anxious participants. In addition, high trait test anxious participants demonstrate less clustering of information in free-recall tasks than do low trait test anxiety participants (Mueller, 1977). Therefore, network distances and recall distances likely had more variability in the data set of the high trait test anxious participants than the low trait test anxious participants. This raises limitations in the method of the current report. During the course of method development, the number of recall trials was substantially increased as participants were having difficulty recalling the 12 words on the list. Despite the efforts of pilot testing, nearly half of the data collected during the recall trials was excluded as it did not meet inclusion criteria developed to ensure stability and validity of the recall data. It should be noted that data derived from the recall study included two trials of delayed recall designed to prompt clustering of information. However, it is possible that because of the substantial variability in recall for high trait test anxious participants, additional recall trials with criteria of

overlearning would be necessary in order to accurately assess cognitive organization with a free-recall task. Future research will be needed to address this issue.

In conclusion, the validity of Pathfinder networks as representations of cognitive organization was only partially substantiated. Specifically, these data suggest that Pathfinder is most valid when using homogenous data sets which is best accomplished by incorporating average Pathfinder networks into data analyses. As such, the Pathfinder method may be limited to examination of group network differences or in comparison of individual networks to a group average network. In addition, current results suggest that the Pathfinder method may only contribute significantly to illustration of cognitive structures when comparisons are made in between-subject analyses. During within-subject analyses, the Pathfinder algorithm does not contribute substantially to recall above that which is assessed by simple relatedness ratings. Finally, high variability in the high trait test anxiety groups for both Pathfinder network ratings and recall data indicates that additional research with a larger sample size and increased number of recall trials is warranted before definitive conclusions can be made regarding the validity of Pathfinder for use in examination of anxiety-related networks.

General Conclusion

This study failed to find an effect of trait or state anxiety on cognitive networks related to test anxiety. Several directions for future research have been suggested including the investigation of different populations with more specific fears, and the investigation of test anxiety with different word categories, which may provide a more accurate assessment of anxiety-related networks. However, current results do not support the cognitive network theory of anxiety. In addition, the validity of the Pathfinder method was only partially supported in the current study. Results suggest Pathfinder is most valid when comparing average group networks. Current results also indicate that the Pathfinder algorithm does not contribute to recall organization above that which is assessed by the original similarity ratings, at least when comparisons were made within-subject. Finally, future research which improves upon the current recall method is suggested before conclusions are made regarding the validity of Pathfinder in populations with high anxiety.

Current results also have implications for applied clinical psychology. It has been suggested that Pathfinder may offer a method of clinical assessment which is less face-valid, and therefore less susceptible to bias than other self-report methods (Melton, 1995). Unfortunately, current findings do not support the validity of individual Pathfinder networks for use in clinical assessment for anxiety. Previously published research in the domain of clinical psychology using Pathfinder has been conducted to assess semantic network organization associated with Alzheimer's disease. Average semantic networks of Alzheimer's patients and normal control participants differed significantly, and the similarity of Pathfinder network associations generated by Alzheimer's patients to an average Pathfinder network generated by control volunteers was predictive of future cognitive decline (Chan et al., 1993; Chan, Salmon, et al., 1995). Therefore, comparisons of Pathfinder networks to standard average networks of

nonclinical volunteers may still offer utility in assessment for some clinical conditions. Validation of Pathfinder using memory measures with Alzheimer's patients is warranted, as well as, research comparing average Pathfinder networks between other clinical groups and control volunteers. In conclusion, additional research is necessary before Pathfinder can be either accepted or rejected for use in clinical assessment.

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Appendix A
Stimulus Words

Words in the Testing Situations Category

1. Test
2. Exam
3. Quiz
4. Finals

Words in the Positive Performance Evaluation Category

1. Successful
2. Brilliant
3. Capable
4. Skilled

Words in the Negative Performance Evaluation Category

1. Failure
2. Unsuccessful
3. Stupid
4. Incompetent

Appendix B
Example Word-Ratings Form

DIRECTIONS:
PLEASE READ THE FOLLOWING DIRECTIONS CAREFULLY

Your task in this experiment will involve judging the relatedness of pairs of concepts. In making these types of judgments, there are several ways to think about the items being judged. For instance, two concepts might be related because they share common features or because they frequently occur together. While this kind of detailed analysis is possible, our concern is to obtain your **initial impression of "overall relatedness or similarity"**. Therefore, please base your ratings on your first impression of relatedness.

Please rate the following pairs of words using the scale below, and **write the number on the line** below the two words being rated. For instance, if you feel that the concepts are not related at all rate "1". If you feel the concepts are highly related you would rate a "9". You can think of these numbers as points along a **"relatedness" scale**, with **higher numbers representing greater relatedness**. In addition, please complete the ratings **in order**, and **do not change ratings** once they are completed.

1-----2-----3-----4-----5-----6-----7-----8-----9

highly unrelated highly related

- | | | |
|----|--------------|--|
| 1. | Quiz | |
| | Incompetent | |
| | _____ | |
| 2. | Unsuccessful | |
| | Successful | |
| | _____ | |

Appendix C

Demographic Questionnaire

Please complete the following information.

Age _____

Race _____

Please circle one:

Sex: M F

What year are you in college? FR SO JU SR Other

Is English your native language? YES NO

Vita

Gretchen Diefenbach received a bachelor of arts degree in psychology from The Pennsylvania State University in 1993, and a master of arts degree in psychology from Louisiana State University in 1996. She is currently completing her pre-doctoral internship in clinical psychology at the University of Texas-Houston Health Science Center. She will graduate this year with the degree of Doctor of Philosophy, and plans to pursue research investigating the nature and treatment of anxiety disorders.


DOCTORAL EXAMINATION AND DISSERTATION REPORT

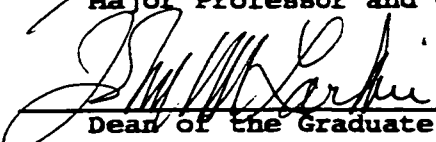
Candidate: Gretchen J. Diefenbach

Major Field: Psychology



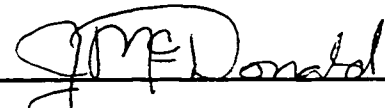
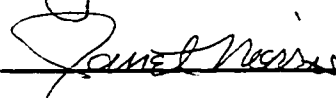
Title of Dissertation: The Role of Trait and State Anxiety in Semantic Network Organization of Information Related to Current Concerns

Approved:


Major Professor and Chairman


Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination:

May 6, 1999